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THE PHYSIOLOGY OF EXERCISE.

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II.

BETWEEN the external sensation and the internal perception stands the time-sense, adapted to the distinction and estimation of the succession; it is really a grosser hearing and sight, for the cochlea and retina do nothing more than distinguish the more or less rapid succession of impressions. The time-sense is susceptible of a high degree of training, as may be learned from intercourse with astronomers and watch-makers. The later chronoscopy has warranted the possibility of determining the educability of the nervous system to a punctual obedience. In the experiments which Herr Donders first made tentatively, the mean of the time which the same observer required to execute a determined movement in accordance with some signal which he saw, heard, or perceived, sunk from day to day to a limit which was soon reached. The result was the same in a small degree which the drill-master enjoys in a large degree, when to his command a single sound responds, hardly longer protracted than to twice the difference in the time required for the sound-wave to pass from him to the nearest and to the farthest man.

Finally, the internal sense also, which has already entered into our considerations, is susceptible of exercise. Before all, the memory is strengthened by practice to a certain degree, and according to its employment in different directions. It may be recorded here that, as I have heard Schleiden relate, Robert Brown was able to distinguish twenty-five thousand species, Kunth only twenty thousand species of plants; and, if Kunth undertook to impress more than that number

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upon his mind, others passed out. The morphologist remembers forms, the mathematician formulas, though he may prefer to work them out anew; the philologist speech-forms and citations, the chess-player games. Personages whose high positions in life require them to recognize many faces have wonderful accomplishments in that faculty. I have myself learned from my own experience that the same person by changing his employment may, if we may use such an expression, change the direction of his memory. I have also observed upon myself the influence of exercise upon the memory. Faraday was, it is well known, accustomed to lament the weakness of his memory. And when I (if I may compare small things with great) was engaged continuously for ten years, as he was during his whole life, with qualitative experiments, I remarked that my former good memory declined, undoubtedly because I needed each day, to continue my work, only the steps of the experiments of the day before. My memory began to improve again when I began to give lectures. Like the memory, the power of the most various mental activities increases with exercise and diminishes with neglect. We hear a great deal said in teachers' associations about how school-youth should not only appropriate what is taught them, but should also learn to exercise their sensations and perceptions, and make their mental powers facile. General and diplomatist, jurist and physician, mathematician and descriptive naturalist, chess-player and mechanician—all are practiced in their peculiar methods of thought. The effects of exercise extend into the emotional life: who would doubt that a Heine exercised himself in giving free course to the flow of his conceptions, in allowing them to strengthen themselves, as it were, in order to draw half deliberately out of the fountain the immortal complaint of self-created sorrow?

There are in psychology few darker points than the doubling of our I in this mental exercise. A final incomprehensible something in us oppose as subject another equally Incomprehensible as object, which is ourselves, yet also really is not, and forces it to a painful exertion, as at another time it compels its bodily substratum to practice itself in a composite movement, with aching muscles and other pains. Whoever comprehends the fundamental fact of metaphysics, that no arrangement and movement of matter can afford an explanation of consciousness even in its simplest form, will never think ultimately of conceiving these processes as mechanical ones.

This confessedly does not exclude our at least ideally, looking through to the play of the ultimate atoms of our present elements, somewhat as Herr Clausius, before our mental eyes, causes the molecules in a gasometer to perform their crossings and reboundings; and we may even confidently anticipate an important result, just the already declared fundamental distinction between exercise of the central nerve-system and exercise of the muscles, connective substances, etc. While in these tissues we deal with nutritive and formative stimu-

lation, by exercise of the central nerve-system is signified, in the first place, the making fluent certain molecular movements, partly through regulation and suitable re-enforcement of the impulses producing them, partly by the elimination of the obstacles originally opposing them. It must not, however, be said with this, that the highly vascular gray substance is not also nutritively stimulated by the activity incumbent upon it. Every thing indicates that, without a proper degree of activity, gray substance wears away as muscle does. But every increase in the fluency of definite forms of motion with a definitely enduring course is a newly acceding moment, indicative of exercise of the central nerve-system.

The more easy unfolding of a frequently repeated molecular movement in the ganglion-cells may be represented under the figure of a water-channel or a stone-slide, in which the path originally built roughly is so worked out and polished by the continuous passage of water, snow, and stones through it, that thenceforth water, snow, and stones reach the bottom surely and quickly, almost as soon as they begin to fall upon the ways converging toward it. All machines are improved with time through the wearing away of little roughnesses, so that their course becomes a more or less evenly or periodically varying one. Since they afterward become shackling through usage, they have, it seems, an age of development, one of bloom, and one of decay; and Tiede speaks of his chronometer as of a living being with a definite period of life. In order to bring nearer to comprehension the facilitating of the molecular movements in the ganglion-cells, it will be well to remember that the tone of a violin becomes softened by long use, as inversely India-rubber, that is not stretched at intervals, becomes brittle. The instructiveness of this comparison lies in its poverty. It shows us the utterly hopeless insufficiency of our knowledge in the face of such mysteries.

Herr Fechner has mentioned a particularly curious case of exercise of the central nerve-system, which sets anew in a clear light the comparatively slight importance of exercise of the muscles. In the Andoyer method of teaching to write, the pupil writes over with a pen for twenty times in succession the identical letters that have been previously written with a pencil, and the hand returns with a swing from the end of the line to its beginning, in order to write it over again without a pause. Ernst Heinrich Weber has observed in the case of his children that the left hand learned to write some at the same time with the right, but it wrote as in a looking-glass. We do not understand how the right side of the brain gained by exercise without the left hand moving during the exercise.

But equally whether we understand it or not, man is adapted to self-improvement by means of exercise. It makes his muscles stronger and more enduring; his skin becomes fortified against all injury; through exercise his limbs become more flexible, his glands more

productive. It fits his central nerve-system for the most complicated functions; it sharpens his senses, and by it his mind, reacting upon itself, is enabled to augment its own elasticity and versatility. Returning to our starting-point, we ask, Is not this one of the means, perhaps the principal one, by which the collectivity of living existence becomes a self-improving machine? As to the crystal, the parts of like structure and properties composing it; as to the whole organism, the elementary organisms whose life makes up its life, so are related to the whole of organic nature the single living existences, that is, the properties and functions of the whole are the sum of the functions and properties of the individuals; and if the individual living being is improved by exercise, does not this also sufficiently explain the progress of the aggregate? Lucid as the supposition appears, on a nearer trial it encounters serious difficulties.

First, only the most highly organized animals are amenable to exercise, or, what means the same thing, trainable. After the generally distributed companions of man, the horse and the dog, the most teachable animal is the elephant. Chamisso found intercourse with the apes on board the Rurik uncommonly instructive, "for," as Calderon says of the ass, "they are almost men," and he made the profound remark that they might be able to bring themselves up to the mark if they did not lack the property which Newton held to be one with genius, steadfastness. Carnivores, with the exception of the cheetah (*Felis jubata*), ruminants, and rodents, exhibit only moderate teachability; yet Herr Fritsch considered the draft-oxen at the Cape of Good Hope wiser than the horse, and in Brazil and Thibet sheep are trained to carry loads. Among the birds, the higher ones are the parrots, starlings, bullfinches, and canary-birds; the falcon ranks with the cheetah in teachableness. Chameleons, snakes, and carp are only moderately teachable. The training of fleas is only apparent; they always perform their tricks under a kind of compulsion. The immense host of other creatures all around us show no more aptitude for training than they do, for the reason that every animal within its own circle has no need of instruction; what we call instinct affords to animals, without effort of the individual, more than any exercise can. What practice could teach birds to build warmer nests, to find the way south more certainly, or bees to solve their geometrical, spiders their mechanical problems? Instinct and perfectibility complement each other as it were in the ascending series of animals to a growing sum, so that, the more instinct retreats before perfectibility, by so much does the living being stand at a higher stage. Secondly, although the animals we have named, and many others besides, are susceptible to exercise and trainable, animals still do not of themselves exercise and perfect themselves, but do so only when man takes them to school. Therefore, the animals around him appear less susceptible to training, the lower the stage at which he himself remains. Higher races of men would

certainly have tamed the beautiful zebra and quagga; the elephant, brought by Hannibal over the Alps, fell back with Northern Africa into wildness. Only nutritive and formative augmentation of advantages which an animal may have acquired in the wild state could come into consideration here, and these would have to be hereditary to lead to perfection in a course of generations.

This seems, thirdly, not to come to pass. No matter for how many generations man cuts off the tail and ears of dogs, tail and ears return with each new brood. The mutilation which the Semitic races have performed on their children for hundreds of ages, and which Islam has imposed upon a great part of the population of the Old World, is not yet chronicled in nature. If, now, artificial defects are not hereditary, how may we venture to suppose that those artificially acquired changes which appear as favorable results of exercise are conveyed through egg and seed to posterity?

To this argument the following considerations are opposed: Although deformities produced by exterior force are not inheritable, we nevertheless see that incontestably internally acquired changes are only too surely transmitted. Of this, the host of hereditary diseases affords an example. Since cellular pathology has shown that the most various heritable diseases of the tissues, the most malignant as well as the most harmless forms, move within the limits of the once given type, the difference appears exposed to light which separates an artificial deformity from a retrogression caused by disease; and it becomes comprehensible why in tame rabbits, the tips of the ears of which may have been idle for many generations, the ear-muscles disappear, and the ears hang down limp; and why the eye and visory substance of subterranean and cave-inhabiting animals waste away. But, even if a deterioration within the type of the species by lack of exercise becomes hereditary, formations dependent on nutritive and formative stimulation, which also remain necessarily within the type of the species, may likewise be transmitted. This appears even to be the case with the inworking of the central nerve-system in certain forms of emotion, of which the growing wild of the at first confiding bird on a formerly uninhabited island furnishes a classical example. Certainly animals in freedom do not, like those under human training, become habituated to definite, frequently repeated functions, yet hunger and love, hatred, cold, thirst, etc., drive them likewise to the frequent performance of certain acts. So, finally, might the innate superiority called instinct (*Kunsttrieb*) have been gradually developed through practice, and the more easily, as a certain degree of pleasure is connected with the execution of series of movements that have become familiar. If, then, instinct does all that is necessary for the maintenance of the species, there is no more room for further improvement or for development in new directions, and the species remains at the stage it has reached as bees and spiders have done ever since man has known them. We may confidently assert that at

the farthest no other actions of the ganglion-cells in the nervous system of these animals are possible than those which serve their particular, instinctive actions. As the artisans from Newcastle-on-Tyne, at the Bureau of Emigration of New York, replied to the question what kind of work they understood, "Packing files," so animals with a perfected instinct purchase their superiority with a one-sidedness which, because they can learn no more, makes them appear as if they had never learned.

Susceptibility to exercise first enters into the animal world when the maintenance of the individual and the species has been so assured, through outer and inner circumstances, that the creature does not need a further particularly one-sided development. We are, then, free to conceive, with an appearance of justification, that the strength of the muscles employed in flight and digging, the thickened epidermis on the palms of the hands and the soles of the feet, the callus on the prehensile tail and the buttocks of apes, the bone-prominences at the attachments of the muscles, and many other similar things, depend on the inherited consequences of nutritive and formative stimulation, while the most diversified kinds of skill may be traced back to inherited concatenations of actions of the ganglion-cells; and this, whether we consider the waves which flow along apparently in a purely mechanical manner in the gymnotus-fin, or in the thousand feet of the wood-louse; or the intelligent posture of the French pointer, which, untaught, and without ever having seen one before, points at the lizard in the sub-tropical shrubbery as his ancestors pointed at the partridge on the plain of St. Denis. With Mr. Herbert Spencer meeting me in the same thought, which I believe, however, I have more sharply grasped, I deduced on a former occasion how, in such transmissibility of educationally derived aptitudes, possibly lies the reconciliation of the great antitheses of the theory of knowledge—of the empirical and the innate views.

Besides improvement by exercise, improvement by natural selection should not be left out of the account, if we would understand the adaptability of organic nature, for a threefold reason: First, there are numerous adaptations—I mean only the so-called sympathetic colorings—for which natural selection, not exercise, seems to afford an explanation. Secondly, plants, which are not less adaptable in their way than animals, do not enjoy exercise. A few phenomena of plant-life, reminding us of callus, and traceable back to nutritive and formative stimulation, belong rather to the region of healing and restoration, which is at this point closely connected with exercise. Thirdly, and finally, we require natural selection in order to explain the origin of the adaptability to exercise itself.

Indeed, the usefulness of exercise in its most diversified forms is in itself a deep problem. If we do not concede, as we can not scientifically, that the adaptive quality originated otherwise than mechan-

ically, we must conclude that in the struggle for existence those creatures prevailed which, by exercise of their natural functions, casually increased their fitness for those functions, or did this more than others, and that the beings so favored transmitted this their happy gift to their posterity for further increase. Thus originated an animal world susceptible of exercise; thus was originated natural selection itself, in the exercise of an important aid; finally, thus became the whole of life, like the individual, a self-improving machine. Herr Ewald Hering was also led to the conclusion that "even those properties of an organism may be transmitted to its posterity which it has not itself inherited, but has appropriated to itself under the particular circumstances in which it has lived, and that, in consequence of this, every organic being imparts to the germ that separates from it a small patrimony which it has acquired in the individual life of the mother organism and laid up for the grand inheritance of the whole race." The more perfectly this conception agrees with the one just unfolded, the more I am sorry that I can not follow Herr Hering when he represents the capacity of living beings to transmit acquired properties as an original power of organic matter, and explains it as a power of reproduction of the same kind with memory. To make the manifold processes on which the different kinds of exercise depend the expression of an original power, appears to me to be rather a darkening than an illuminating generalization. Herr Hering finds the *tertium comparationis* between the transmission of acquired bodily properties and memory in reproduction. But I see no similarity between the facile rolling-off of a definite molecular process in the ganglion-cells of the individual—which is memory—and the return in the offspring of a molecular arrangement imposed, in consequence of external conditions, upon the parent, which would be the transmission of acquired properties; and, if I did see a similarity, it would for me retire before the distinction that, as the name (*Gedächtniss*) indicates, memory is an attribute only of thinking beings. Herr Hering's unconscious recollection is a side-piece to the idea which men since Plato, to the injury of science, have suspected as a shaping force in the "great and little world," or to the life-force, in the face of which all the problems of physics and chemistry should lie open. Unconscious recollection is, moreover, not acceptable to me, because Herr Haeckel has eagerly appropriated it, and given it an important part in his plastidule theory.

I hold this play with groundless analogies to be the more hazardous, since, finally, it can not be strongly enough sounded that the transmission of acquired properties which we have thought of, with Darwin, Herbert Spencer, Hering, and many others, as possible and real under certain conditions, is proved, on further reflection, to be perfectly incomprehensible.

We are indeed indebted to the mechanical theory of gases for more just conceptions of the minuteness and the number of molecules;

viewed in its light, the number of possible arrangements in the ovum and spermatozoön grows into immensity. If we could imagine the head of a spermatozoön as large as the Great Eastern, and the space represented by it filled with a wheel-work as fine as that of the smallest lady's watch, our figure would still be far from giving any kind of a representation of the ultimate division of matter. It is thus clear that the head of a spermatozoön affords space and opportunity for the endlessly numerous arrangements and various motions on which the innumerable types and properties, with which this apparently so simple organism is charged, finally depend. It may then, at all events, be conceived that parental dyscrasies communicate themselves through the blood to the germs in the testicles and ovaries. But now let a group of ganglion-cells in the brain, if we may speak thus, be played upon to a certain molecule-dance-figure. The blood can not be changed by that. Consequently, the threads of the *plexus spermaticus internus* must so work upon the semen-cells in the seminal canal, the egg-cells in the after-growing Graafian pustules, that each act of exercise in the course of growth leaves its mark on the egg or on the spermatozoön, and that it is followed after years by the natural culmination of the same molecule-dance-figure in the corresponding group of ganglion-cells in the man or animal that has grown up out of that egg, or with the aid of that spermatozoön. How the *plexus spermaticus internus*, the connection of which with the brain is only of the loosest character, brings this to pass, can not be found out. The conditions are no more favorable for the comprehension of the kinds of exercise resting upon nutritive and formative stimulation.

As we have already pointed out, it appears that we might, in order to verify the transmission of acquired properties, invoke the example of hereditary diseases, from which our ancestors were in all probability free, which chiefly visit more highly developed manhood, and the transmission of which consequently resembles the transmission of acquired properties. Still, we may question whether the first epileptic attack, the first *migraine*, followed injuries which came upon a sound adult, or whether the foundation for them was not laid in the egg or the spermatozoön out of which the first sufferer grew. There remains, for the confirmation of this view—we will be honest—the transmission of acquired peculiarities, an hypothesis drawn solely from the facts illustrating it, yet quite obscure in itself, which receives only doubtful light through Darwin's "pangenesis."

I believe now, gentlemen, that I have justified the expression with which I introduced to you my intention to speak of exercise—that is, that it deserved a place in the scientific order of the day; yet I need not say explicitly how far I am from entertaining the thought that I have contributed anything essential to the fulfillment of that object. I consider that I have succeeded no further than more sharply to define the eventual phylogenetic office of exercise and the direction of the

evidences to be supplied than is usually done in the presentations of the Darwinian theory. In the immense field of research opened by Darwin after the fall of the zoölogical-paleontological dogma, the cultivation of which will employ the plowshares of many generations, we have plainly indicated to us one point where the work is urgent. On the other hand, a surer foundation might now be laid for the determination of one of the practical questions relating to exercise.

All are agreed as to the importance of bodily exercise for modern civilized mankind. With the knightly tournaments of the middle ages, in which, moreover, only an extremely small minority ever took part, physical training has more and more declined. Jean Jacques Rousseau, by his educational romance, gave the impulse to a movement that was fast taken up, especially in Germany, and, borne through the national and military struggles of the war of freedom, has culminated in the German turning.

Physical exercise had been pursued by us in this form for half a century when doubts were raised as to its fitness. To the German turning was opposed a theoretically devised form of physical training, the so-called Swedish movement, or gymnastics, the ground thought of which was the limitation of the exercises to extremely simple, although varied, motions. Since these movements were performed against resistance, a methodical strengthening of all the individual muscles was thought to result from them, and the true ideal of an athletic muscular system to be reached.

Again, from another point of view do we hear the superior fitness of the German turning doubted. The European nation which stands foremost in physical accomplishments, and which attaches the highest value to bodily vigor, the English, has till very recently known nothing like the German turning. Separated more than ever from the Continent during the French Revolution and the Empire, it was little affected by the movement of which Rousseau was the pioneer. Jahn's arguments, with their somewhat German-chauvinistic coloring, found but little acceptance there. The English, however, had less use for turning than the nations of the Continent. Thanks to the rural life of the wealthy classes and the common training of the youth in public institutions, a number of national games and contests (riding, rowing, games of ball of various kinds) had been formed, which afforded a superior empirical schooling in the various movements called forth in them; as the achievements of the English mountain-climber, who has just put Chimborazo under his feet, sufficiently illustrate. The passionate interest felt through the length and breadth of Sir Charles Dilke's "Greater Britain" in the annual contest between the dark-blue Oxford and the light-blue Cambridge oarsmen on the Thames can only be compared with the enthusiasm of the Greeks for their national games of competition, and goads the youth to the most earnest exertion.

Here we have the other extreme. The *κατ' ἐξοχήν* practical people rejects our physical exercises as too theoretical for its taste. The English at least did not understand at all, when, in answer to the question what sports we played at, an effort was made to explain our tool-gymnastics to them.

When we undertake to judge, in the light of our view into the nature of physical exercise, between these three forms, the German turning, the Swedish movement, and the English sport, the utter worthlessness of the second form for the bodily improvement of a healthy youth manifests itself at once. We have found that physical culture is not only exercise of the muscles, as it appears on a superficial view to be, but is quite as much, yes, more, exercise of the gray substance of the central nerve-system. The physiological value of the Swedish movement is expressed in the simple remark that it can strengthen the muscles, but has not power to make composite movements fluent. Now, in an extremely theoretical case, a physical training is thinkable, by which single muscles of a Caspar Hauser could be cultivated by gymnastics to a lion-like strength without the victim of such an experiment even learning to walk. The Swedish movement is only good for the purposes of physicians, to keep up or restore the efficiency of single groups of muscles.

Turning our attention to the relative worth of the German turning and the English sport, the latter evidently responds more than the former to the demands arising out of our physiological anatomy. Were the end masterhood in running, jumping, climbing; in dancing, fencing, riding; in swimming, rowing, or skating—then nothing could be more advisable than to practice equally and directly the necessary concatenations in the actions of the ganglion-cells, without pausing at the not practically applicable preliminary and intermediate steps of the German turning.

The German turning, however, offers not only the advantage of furnishing to any number of youth, of every age and condition, opportunity for exercise with the smallest amount of external preparations, and independent of often unattainable external conditions; it not only implies the moral earnestness of an effort that proposes self-improvement without immediate practical advantage as an ideal aim, wherein the superiority of the intellectual training sought in the German gymnasium may also be discerned; but, furthermore, the ingenious selection of German exercises, approved and refined through a long experience, results incontestably in a more equable perfecting of the body than can be attained where, as in England, the individual, following his own casually determined inclination, applies himself with ambitious enthusiasm to rowing or riding, to ball-playing or mountain-climbing. The youthful body, thoroughly trained after the German method, enjoys the extraordinary advantage that, like a well-instructed mathematician, it is provided with methods for every problem, with

ready forms of movement for every situation of the body. Put, for example, an English boy and a German boy on a road across which hurdles are thrown: the English boy will be sure to climb over somehow. According to the height of the impediment, the German boy jumps, or he climbs, props himself, and swings himself over.

Nothing prevents the German turner at pleasure carrying his more theoretical training into practical and immediately available forms of exercise, in which he, since he has learned to learn, speedily attains the skill which his natural ability permits to him; so we have been told that the gymnasiast soon does as well as the real-scholar in the laboratory.

After all this there can be no doubt that German turning, in its wise mingling of theory and practice, exhibits the happiest, yes, the most adequate solution of the great problem with which pedagogics has been busy since Rousseau—a truth which, after a short obscurity, is now hardly contested, but the physiological principle of which a few are beginning to understand.

I further remark that I do not class with German turning the so-called order-exercises, which, over-estimated as preparatives to exercising, and a lazy-bench for inefficient teachers of turning, belong, in my opinion, to the Kindergarten.

Hardly any progress in the knowledge of the laws of exercise has been made since Milo of Croton's famous experiment with the calf. Yet we are indebted to the creator of psychophysics for the beginning of the inquiry which is here possible. Herr Fechner daily for two months raised and dropped a pair of nine-and-a-half-pound dumb-bells conformably to the beat of a second-pendulum, from the hanging position of the hands to over his head, raised them and dropped them again, till fatigue compelled him to stop. The curves, the ordinates of which indicated the number of elevations daily, are instructive in a double respect. At first the exercise appeared to bear no fruit, then the results came out all at once; but they soon reached their limit. Volkmann had a similar experience in exercise of the senses. Herr Fechner's curves, in the second place, do not rise steadily, but in a serrated manner, according as weariness or increasing facility prevailed. These experiments might be made of useful application in the inspection of recruits for particular purposes.

Like individuals, so are whole peoples susceptible to exercise and of being trained; and here also an originally higher talent often does not go so far as continuous practice. The hardy, tough, North-German stock resemble the unpromising land, conquered only by obstinate labor, which we till. The Prussian is the self-made man among the peoples, yet he has not made himself without some help sent him by a favoring destiny. He has been eminently made, trained, and exercised through the care of a series of chiefs, unique in the world's history, culminating in the Emperor William. The present memorial day re-

calls one of the numerous acts of wise care whose blessed fruits we meet everywhere in this city, in this state. This institution, created when Prussia was still a feeble, small power, has grown with the state in importance and certainty of aim, and is now the nursery of physicians for by far the largest part of the Prussian-German army and for the Imperial German fleet. Whether scholar or teacher, each one of us feels how, with this elevated position of the school, his duty increases to perfect himself by means of incessant conscientious exercise.

NATIONAL NECESSITIES AND NATIONAL EDUCATION.*

By BENJAMIN WARD RICHARDSON, M. D., F. R. S.

I ASK myself if the system of education at present going on in our nation is a system which has a proper relation to the necessities of the nation. I look round me, to see the nation in chaos of thought and action; in what Mr. Gladstone has correctly defined as social revolution in one part, and mental revolution in all parts; mental revolution that might, by merest accident, by one or two days' shortness of food, from failure of foreign supply and panic thereupon, pass, after a few years of further chaos, into physical revolution. And the thought which occurs to my mind, as it must to all who think, is, Are we educating to prevent catastrophe? Are we educating the young to become useful, independent, and capable working members of society, ready to work with muscle as well as brain, in orderly and profitable form, or are we educating them to become mere troublers without design, repiners without hope, schemers without self-endurance, masters of the forces of Nature herself, knowing how to use them for temporary, selfish, insane objects, but not knowing how to apply them for splendid results and the general good?

The national necessities as the bases of national education are, first and foremost, these: that although in the early days of youth the three simple elementary educational practices of learning to read, to write, and to calculate, are necessities for the time, they are comparatively valueless unless combined with further necessities of a physical kind—namely, sound and systematic muscular training; freedom of breathing, and circulation of the blood; practical training, so that the body can be structurally built up and sustained in health; preparation for all duties requiring precision, decision, presence of mind, and endurance; and readiness to acquire any craft or handicraft that may bring a useful living; in a word, an education that shall bring the

* From a Lecture delivered before the Society of Arts, April 28, 1882.

mental and physical qualities of every person into faithful harmony and good-will.

I, like some of my colleagues at the School Board, would break up the monotony of the schoolmaster and the schoolmistress, and would give those excellent workers as much variety of teaching as any of them could desire. But that variety should be physical, not mental; play, rather than work; training of the muscles, and, I may say, of the skeleton too; of the lungs, of the heart, of the digestive organs; of brain and nerve for action—not of brain alone, and again brain, and brain, hour by hour, all the day long. I, like others of my colleagues, would encourage economy, not by keeping things as they are, but by saving some part of the two fifths of the money now expended on teaching to spell, and by laying it out in teaching how to walk with grace and ease; to sing with correctness; to swim; to learn the use of the arms, and fingers, and hands; and to become men and women in the strict sense of the word, without danger of retrograding a hair's breadth in the Darwinian line.

I said, in my address at the Health Congress, at Brighton, what was quite true, that I had never in my life seen a healthy child, by which I meant that I had never seen a child that had not in it either some actual or latent constitutional disease. Touching the subject now in hand, it is equally true to say that it is all but impossible to find, in the board schools of our large towns, any semblance, critically viewed, of health. Constitutional taints, which under favorable circumstances may often be concealed, and which may or may not be apparent, are there. Various conditions of disease are there, independently of the tendency from heredity; there of themselves, in some irregularity of body or limb, in some imperfection of sense, in some deficiency of quality of blood, in some feebleness of respiration, in some nervous irregularity of function, in some shade of mental aberration.

The field of disease which is presented in some of the schools situated in crowded localities is indeed a sight at once for anxiety and pity. To the eye of a physician who, like myself, has spent many years in dispensary practice, it tells a story which is absolutely painful, if he permit the results to be calculated out in his mind at leisure hours; if, that is to say, he compares what he has witnessed in his survey with what he has learned, from long observation, of the meaning of the phenomena in the history of life. It is not necessary to strip the children, percuss and sound the chest, examine the spine, or practice any of those refined arts of diagnosis with which he is familiar. He reads from the indications of temperament, of expression of countenance, of color of skin, of position of limb, of build of body, of gait, of voice, sufficient outward manifestation to discern what is the true physical state, what are the stamp and extent of disease, what is the vital value of the lives generally that are before him.

Foremost among the evils which are thus presented to him are those conditions of disease known as anæmia and cachexia. Strictly, these are not diseases like diabetes, bronchitis, or defined affections having a regular course, but they are states of diseased form, which by their presence indicate a faulty nutrition at the period of life when good nutrition is most required, and which can not long go on without insuring the construction of an impaired bodily organization. The blood is not being duly oxygenated, and food, therefore, though it even be fair in quality or quantity, is not properly applied. The nervous system is imperfectly built up; the skeleton is imperfectly built up; the muscular system is imperfectly built up and sustained. How can the improvement which is called scholarship be turned to fitting account in such recipients of it? I watched recently the afternoon working of a large class of scholars, and counted one third of them under the most decisive influence of these conditions of disease. Of the affected, there would not be, in the ordinary averaging of life, twenty years of existence under the course that was being followed. The one saving clause in their case was development by physical training, and that was withheld. The one destroying clause in their case was over mental work, without the physical training, and that was assiduously and regularly supplied.

With or without the anæmia and cachexia, there is the constitutional disease, struma or scrofula, present in these classes. The instances of this kind, in varying degrees of intensity, are most numerous. This condition, again, is a mal or bad nutrition. It, as much as cachexia and anæmia, with which it is so often allied, is fostered by the prevailing system of mental pressure.

With these two conditions before the eye, there is to be seen here and there in the classes, of both sexes, but of the girls especially, the specimen of the phthisical or consumptive subject. In a class of fifty I pick out three thus doomed, if their circumstances be not changed, six per cent, certainly a moderate proportion. The disease has not positively developed, but the probability of its developing is all but certain, unless it be checked by the one or only remedial or preventive method—freedom from nervous exhaustion, combined with physical exercise in open breathing-space. Such preventives are not supplied, but undue nervous exhaustion and confinement are both supplied, and so the fatal disease is systematically fanned from latency into activity.

Spinal deformity and irregular construction of the skeleton is another condition of disease, or actual disease, readily detectable in these classes.

Miss Löfing, speaking of her experiences as to the girls which have come under her notice, reports that they are, as a rule, very flat-chested, that there is evidently much spinal distortion, and that lateral curvature of the spine is common among them. This, which is equally true in respect to boys, is accounted for by Miss Löfing in terms which

show that the present school system does more than simply permit the mischief that is progressing, it actually fosters it and promotes it. Asked "to what the effects are chiefly ascribable," she replies: "A part is ascribable to home neglects; but the greater part of it is due to excessive and prolonged constraints under the common-school conditions: too long sitting on badly constructed seats; but, with good seats, they are kept in bad positions in long writing exercises. The common bad position is, indeed, prescribed by the Government School Inspectors. I have found that, to obtain the school grants, the children are so constrained as to exclude the exercises that are needed for their bodily development."

The present system is not only a violation of physiological but of psychological law. The powers of receptivity of the minds of children of different ages have been tested experimentally, with as much care as physicists take when they are treating in their experiments on the relationships of ordinary matter to force. Certain brains can take in so much, and no more, according to age. The capacity grows with cultivation and skillful teaching, no doubt, but it must be permitted to grow. In the very young a lesson of a minute may be all-sufficient. Later, of three minutes, five, ten, fifteen, and so on, to one hour, two, or three. But to this there is a limit, and it is probable that, with the best scholar of primary-school age, the powers of receptivity rarely extend beyond a period of two hours and a half of direct teaching. Teachers of various districts, and of different countries, have testified in respect to this point, and while they have explained, from direct observation, that the receptivity varies in different children according to difference of temperament, physical health and build, as might very well be expected, the receptivity at one time, in all children, ceases at the end of three hours.

Proposed Reforms.—From these considerations let me now turn to the reforms which we, who are urgent as to reform in the present educational system, have in view. We reason that the existing system is not a basis for the national necessities. We are of opinion that in the future the education of a mental kind now being supplied will be imperfect and doubtful, nay, it may be of dangerous use, unless it be so laid out with physical culture that a perfect or comparatively perfect health of body shall go with it and sustain it. We urge that, as we must either educate health or disease, it is best to educate health.

The design we have in view, then, includes several heads, which I may arrange in the following order:

Physical Culture of the Body.—We urge that education should be so distinctly physical, that the body should be in no respect less improved than the mind at the close of the educational career. We follow, in this regard, the teaching of the Platonic philosophy, in which the master insists that the symmetry of mind and body be cul-

tivated and maintained, without which there can not be beauty, there can not be health. We urge that this is the only sure way of keeping up a strong and vigorous and independent population, that shall understand how to utilize the home resources of land and industry, and keep the land and industry in the possession of our and their descendants.

The system of education that is now being carried out seems to us to promote in no way whatever this necessary intention. In the "standards" we find no efficient instruction of a technical kind that even in the barest hypothetical style teaches the principles of useful arts and appliances. Practical details of industries and of modes of learning industrial occupations are thought to be of less importance to the scholar than a knowledge of geography, construction of language, physiology, and history. It is no wish of ours to ignore studies of the kind above named, but we consider that elementary instruction in details of inventive and industrial pursuits holds a first place, and that in a country like ours in which so much, in which, in truth, almost everything, depends on individual perfection in some useful art, such elementary instruction ought to have the place it deserves at once and for good. We think, moreover, that the instruction should not be purely theoretical. We contend that it should include elementary training in useful work of a practical kind. We do not see why work-rooms should not be set up in schools, in which boys should be taught the use of the lathe; the beautiful art of wood-carving; the skill of the draughtsman; the method of distinguishing metals, and other simple experiments in chemistry; the arts of swimming and riding; the art of distinguishing colors and signs at a distance; the practice of mensuration, and a number of other good and useful branches of physical learning, which, whether the boy remain at home or whether he emigrate to another country, will always be to him a direct assistance, a means of earning his bread, and an insight and test of his particular ability or aptitude for the vocation by which his subsistence will be most easily obtained.

Extending this principle of practical teaching to the female sex, we would have the girls well trained, both theoretically and practically, in those occupations which in the course of life fall more distinctly under their exercise, management, or supervision. We know that in the schools at present girls are taught sewing and a few other useful industrial accomplishments. We would extend these instructions. We would have the girls instructed in modeling; in the art of coloring and painting on glass and porcelain; in the various processes of selecting, sorting, preserving, and preparing foods for the table; in the cleaning and ornamentation of drawing-room ornaments, and in all the works pertaining to domestic life. The girls in our schools would, as we believe, make more rapid progress in mere book-learning if one half of the time now devoted to books were devoted to that

other branch of practical education which forms the greater part, in practice, of the future of the womanly life. We consider that evidence in proof of this belief has already been offered, and we suggest that a girl trained in the manner now described would, in this country, or in any other country into which she might emigrate, be far better fitted for the duties pertaining to any station she might hold, than if she were simply dismissed from school primed with the standards, and standardless.

LIFE-LEARNING TENDENCIES.—We contend, secondly, that the education of the young of all classes, and of the poorest classes chiefly, should be so framed as to lead to the inducement of making the acquisition of knowledge a taste instead of a task, a pursuit instead of a labor. We contend that if the present system is pursued—in which children who are not by heredity born to mental occupation, and who are not physically privileged to acquire information, are, by sheer force, driven through the hard and fast lines, fenced out by the books called standards, at a pace that shall make them complete their education irrespectively of temperament, health, ability, before their thirteenth or fourteenth year—the pressure, amounting in every case to a hardship, will merely have the effect of causing them to cease to learn when the pressure is taken off. We insist upon this, that the system shall be so modified that there shall be no mental pressure at all, but a mixture of mental and physical teaching which shall bring the mind into desire for knowledge after it is freed from the necessities to acquire it.

APTITUDE FOR PRODUCTIVE ABILITY.—A third advancement upon which we lay great stress is, that the educational system shall be of a kind that shall render the body of fitting aptitude for productive ability. We argue that, unless discrimination is used by the teacher for detecting the natural or hereditary capabilities of the scholar, there must be failure in result of the most serious kind; failure that will tell upon all the productive industries of the country, so that agriculture, the various industrial arts, the various labors which call for muscular skill, activity, and endurance, will be sacrificed, or largely reduced in effective value. In insisting on this practice of developing productive ability, we are sustained by the belief that nothing could be lost by the effort in the way of actual education. We are of opinion that the time saved by the adoption of varying conditions of school-work would prevent the injuries now incident to the fixed rules under which the educational system is enforced, and in this view we are supported by the opinions of the most practical teachers.

We maintain that courses of physical training such as we wish to introduce would have a distinct formative effect in mental habits. This is especially seen in the industrial and reformatory institutions where the same principles of mixed physical and mental training have been adopted as prevail in the district half-time schools. A draft

report prepared for the consideration of the Education Committee says of them :

"In the long-time schools, during the time the boy is kept waiting under restraint, his mind is absent from his lessons, which are commonly so uninteresting as to be repugnant to his voluntary attention, and his thoughts are away on cricket, or some sort of pleasurable play, so that he generally only returns, upon call to the lesson, as to a task to be got rid of. Under the restraint of separate confinement in a prison, the mind of the young criminal can not, as is shown by his action on release, have been occupied with compunctious visitings of remorse, as commonly assumed. His thoughts are of his ill-luck under the wide chances of escape of which he has had experience during all the time he has been at large before detection, and of how he may have better luck when he gets out. He is exhorted to be good : but the child of the mendicant or of the delinquent does not see his way to doing other than he has done before ; and why should he, so long as he feels his inaptitude of hand and arm for industrial work ? Be this as it may, under the common conditions of restraint in the district schools, or in the reformatory schools—all of which, comprising some thirty thousand children, are now of necessity conducted on the half-time principle of varied physical and mental teaching — the pupil is placed under entirely new and opposite conditions, by which bad thoughts are excluded and good thoughts induced and impressed from day to day by practical work from the like of which he may hereafter get something good for himself. In the morning he is roused out of his sleep to attend to his head-to-foot washing and his dressing. Then he has to go with others to his breakfast ; after that to the school, where, with his class, he is kept to the simultaneous class lesson without waiting, to which he willingly gives himself, as it is not over-wearisome, like the lessons of the long-time schools. He may next have to fall under the drill-master or the gymnast, and, if he stumble or fail, he is jeered by the other pupils, or reproved by the corporal ; but he soon participates in the zeal and competition of common lively action. He may on the following day have a swimming-lesson. He may next have some naval exercise at the mast, where, unless he holds on, he will fall into the net spread beneath to receive him. Then he has to go to the workshop, where the work-master—in carpentry, in shoemaking, or in tailoring—keeps the mind, the hand, and the eye, of the pupil intently occupied. His day's occupation may be varied by free-hand drawing, so useful to handicrafts, or by lessons in singing, or, if he be a very good and apt boy, by lessons in instrumental music. The enumeration of the incessant occupations may sound as of severe labor ; but the course is varied by "relief-lessons," and it becomes so little irksome that an interruption is disagreeable, and an exclusion from any part of it is acutely felt as a punishment. When some parents exercise their right of taking away children from the district school,

the children are not glad, but commonly cry at having to leave the institution, to part with their playmates or their workmates, and to go home. As the physical and industrial exercises have been improved, desertions have diminished and the outcomes bettered. From morn until night bad thoughts are much excluded, and comparatively good thoughts—thoughts of doing better for themselves by work and wages, and by all honest and esteemed position—are generated and impressed. The teacher can not look into the mind and see what effects, or whether any, have been produced by his precepts. But the drill-master or the work-master does see the valuable primary moral principles of attention, patience, self-restraint, prompt and exact obedience, in outward and visible action. The general result is that the pupil gets interested in what he does, and does it with a will."

We are strongly of the opinion that by the introduction of physical training the end will be accomplished of reducing natural crime.

Lastly, we submit that, to insure the future happiness and serenity of the people of the future, the children of the present should have their mental and art training varied by making the subject of recreation a scientific branch of study among all who are engaged in educational work. In such advance, we should have the means for recreation made the means for imperceptible instruction in bodily and mental powers, so that, having never unduly severed them from the tastes of the scholar, they shall be true resting-places, useful as well as pleasing diversions from mental and physical labor.

I have now put forward our programme. It is framed on what we conceive to be the basis of national necessities. A few concluding paragraphs may be taken as proposed resolutions to explain the mode in which we would carry out the reforms we have in view:

1. We propose to lessen the tasks of a mental kind in all schools, by the introduction of what is practically a half-time system. Believing that the brain of the child under fourteen years of age is sufficiently charged, to be safely charged, when it has been subjected to three hours work in book-teaching, we assume that this period per day of such teaching is sufficient for all useful and safe advancement, that the children would have more than they could learn, and would retain more than they need retain on this plan. We propose at the same time to make inspection into such book-learning less critical and less severe, with an institution of inspection into physical capability as a part of the inspection, in place of the part given up to book standards.

In connection with this department we propose that there should be at stated times a physical inquiry, by competent authority, into the health of every school and every scholar, and that as much special encouragement and reward should be given to scholars who present the best *physique* as to those who present proofs of superior attainments in the standards.

We propose further that this great change shall be effected by

utilizing the time thus taken from books in application to lessons of play, exercise, or work that shall be useful in developing the body, and in making it apt to attain proficiency in physical arts and sciences. We would suggest that, in the school itself, the means for this physical instruction should be provided; but we would not by any hard and fast line hold by the school as the only place. If it were found in any case that a scholar had the means, in his half-time, of following any proper and profitable occupation without injury to himself, we should let him follow it, by which plan, as we believe, the sting of the compulsory clause in the education act would be most effectually blunted.

2. We propose that, while the mind of the child shall not be surcharged with book-learning at a time when the body is in the most critical stage of development either into a sound and helpful or into an unsound and helpless body, there shall be made a provision in the school itself, by which education shall be allowed to go on after the usual prescribed time, in which it is presumed that the education is completed.

3. We propose, in the introduction of physical education into schools, that it should be at once of the simplest and best kind; not a system of one particular character, but one which should combine everything that is useful in various systems, and which should interest the scholar, while it develops his physical life. We agree with an observation made by Mr. Charles Roberts, in a letter in which he says:

> I have examined with some care, from a physiological point of view, the various systems of physical education, but I am not satisfied with any of them. The military drill, in use in many schools, puts too great a strain on the lower limbs, and too little on the arms and trunk, and, though the exercises are useful for discipline, they are monotonous and wearisome to children, and may be injurious, by inducing flat-foot and other deformities of the body. On the other hand, the exercises in ordinary German gymnasiums are generally too severe for children, and not sufficiently under the control of the non-medical teacher; their expense, moreover, places them beyond the reach of elementary schools. The Swedish system, again, as taught in the board schools, lacks spirit and energy, from the entire absence of apparatus, and therefore of motive, to attempt or complete a definite object—a defect which Miss Chreiman's system has removed to considerable extent, by the limited use of simple apparatus.

4. We propose that there should be introduced into the system what may be shortly explained as systematic training of the senses, so that the senses of sight, hearing, touch, and even smell, should be brought up to the best standards of perfection. Such training, we are of opinion, could be carried out by means of lessons and of simple apparatus, and would, in the course of carrying it out, afford facility for practically testing the capacity of every scholar, and his fitness or unfitness for the after-duties he may be called upon to undertake. In

America, they have had appointed tests for the proof of color-sight, so that it may be determined, when a man applies for duties in which color-sights are required, whether he can distinguish color. If our design were in operation, no scholar would leave a school without being made fully acquainted with his particular failure or capacity for this and such like occupations.

5. We propose, finally, to use the time that we wish to extract from book-learning, in some, and indeed in a free degree, in the cultivation of certain of the more refined and pleasure-building arts. First among these we would place music, as the primitive of recreative pleasures. We observe that our children are well and happy when they can sing; we see men and women gathered together, and find the height of mirth and happiness when somebody gives a song or a tune. In the most refined society, music is the joy of life; in the lowest dens, men, hardly above animals, when they meet to be amused, sing. It may be that in all these positions the music is very bad, but it is there, and it extends through creation. Here, therefore, is the first recreation to be scientifically studied. Make a nation, we say, a musical nation, and think how you have harmonized it, socially, morally, healthfully. We can not begin to teach this recreation too early or too soundly.

We ought to begin by making the learning of notes in succession —the scale of musical chords—coincident with the learning of the alphabet. Next, the intervals should be taught, in a simple but careful way, so that melody may be acquired, and the art of sight-singing attained. From this elementary basis should follow the simplest forms of time, after which a plain melody could be read with as much ease as the reading of the first story-book. Simple part-songs, leading to endless delight, would succeed in exercise; and a true and natural language in sweet sounds would be the property, in one generation, of all the nation. In addition to music, we would, as a matter of course, introduce other pleasant recreations, such as dancing, gymnastics, and all those muscular games and exercises which, by discharging naturally the nervous force, relieve the mind of mischievous intents and provocatives to destructive habits.

This is the programme we would put before the nation, in respect to the grand revolution we consider necessary, of placing national education on the basis of national necessities. Should it be urged that what we propose is too essentially physical or muscular, we answer that all education is, in the strict sense, physical and even muscular. Speech is muscular, expression is muscular, writing is muscular, composition is muscular, as much as mental. It is as purely a muscular act to decline a Greek verb as to walk across a tight-rope; only that the muscular movement, hardly so refined, is more obscure. We meet two men, one of whom is seen to move with ease and grace, the other with dullness and weight. We say, how accomplished the one, how un-

couth the other! We hear two men discourse—the one with elegance, precision, style, the other with hesitation, blundering, rudeness. We say, how accomplished the one, how uncouth the other! In all these cases, muscular force has played its equal part with mental aptitude, or inaptitude. We see a man who has not been educated to grace of manner, or speech, or thought, assuming the part of a man of grace, manner, and thought, and, by much study, sustaining the character for a short time, as on the stage. But we know that man only acts; he is not trained to the muscular skill that can carry him through all parts of life with equal grace, though he may, by intense labor, attain a minor part, and be perfect in it.

We know that no one who late in life enters a vocation requiring certain qualities, like that of a physician, a surgeon, a preacher or pleader, a commander, a pilot, an engineer, a player, can gain that full self-possession which comes, as it is said, naturally, to the man who has been from early life trained in the work. Here again the failure we affirm is muscular as much as mental. The concealed muscular mechanism is not in working order. The mind may issue its commands, but, if the muscles fail to obey, the mind, like a general whose red-coats are undrilled and impervious, may break itself to imbecility and produce no results beyond hopeless and helpless confusion and dismay.

So we contend for the physical education of all our young, on the lines I have laid down, as the stirring want in this stirring time. Our intention is to make this nation a nation of heroes as well as scholars; a nation that the sculptor can describe as well as the historian; a nation that can hold its own in the scale of vitality, and protect its own by the virtues of courage, physical prowess, and endurance, as ably as by statesmanship and knowledge, more ably than by expediency and craft.

ACOUSTIC ARCHITECTURE.

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IN the construction of a building in which large numbers of people are to be gathered together to listen to music or speaking, it is highly important to consider the conditions which shall best allow the sound to be carried from the musician or speaker to all of the hearers. It is the aim of the present article to place before the reader an outline of the art of so constructing buildings, and to present certain general principles upon which acoustic success depends.

The subject divides itself naturally into three parts. In the first is considered the effect of the condition of the air within an auditorium

upon its acoustic qualities, and it will be shown, as would naturally be expected, that the condition of the medium which conveys the sound exercises a very considerable influence on the facility and accuracy with which the sound is conveyed. In the second part is considered the effect of the arrangement of the walls which inclose the auditorium, and of the materials of which these walls are composed. In the third and last part there are discussed several minor points, attention to which will aid in the securing of a building which shall be good and not bad for sound. These three headings, it is believed, will cover the whole ground.

It seems almost self-evident that the condition of the air, which is the medium by which sound is conveyed from one part of an auditorium to another, will exercise a considerable effect upon its acoustic properties. An experimental inquiry shows us that such is the case. What peculiar condition of the air is it that affects the transmission of sound? Whether the air is hot or cold, wet or dry, whether it contains a larger or smaller percentage of oxygen, nitrogen, or carbonic acid, seems to have no effect on its acoustic properties. But whether the air is quiet and mechanically homogeneous, or whether there are mingled draughts of hot and cold air moving in various directions, does seem to have a considerable effect. In other words, the motion of the air within an auditorium does have a very perceptible effect on its acoustic qualities.

Probably most readers have noticed, or in any event they have seen recorded, instances in which sounds of very ordinary intensity have been heard, and heard distinctly, at a very considerable distance from the source. In particular, the author remembers an instance which came to his notice one summer afternoon, while resting half-way up the side of one of the hills near the Green Mountains. The hill sloped gently to a meadow at the foot, and its sides curved somewhat like the walls of an amphitheatre, of which the meadow was the floor. Nearly a mile away, across the meadow, a man was mowing grass with a mowing-machine drawn by horses. The day was slightly cloudy, and from the mower, up the side of the hill to the observer, was moving a slight, hardly perceptible breeze. The air was optically very clear, and appeared to be rather dry. The click of the mowing-machine was heard with wonderful distinctness, but the author was not a little surprised when, the machine having stopped for the moment, the "Go along!" of the driver was plainly heard as he urged his horses on. Not only were the words plainly intelligible, but the provincial twang peculiar to the country-folk of that region was distinctly distinguishable. Here the human voice, raised probably very little above the ordinary tone, and not at all above that of a preacher in his pulpit or an actor on the stage, was distinctly heard, and with all its peculiarities of quality, nearly a mile away.

Another instance is that mentioned by Sir John Ross in his account

of his voyage to the polar regions. He says, "I found no difficulty, in that cold and quiet air, in conversing with a man a mile away." It will be noticed that in both of these cases the air was mechanically homogeneous; that is, there were no alternating currents of hot and cold air.

In striking contrast with these may be mentioned the condition of the air as a vehicle for sound in the burned district of Boston, just after the fire had swept over it. There were many places, where there was a mixture of hot air, smoke, steam, and currents of cold air, in which the shouts of two people hardly a hundred feet apart, although audible, were so confused and indistinct as to make communication entirely impossible, and this too in quiet parts quite remote from the scene of conflagration. This effect was noticed when there were mingled currents of hot and cold air. That is, the air was mechanically heterogeneous. Humboldt speaks of the great difference in transmissive power for sound of the tropical air during the day and at night, and attributes this difference to the homogeneous condition of the air at night as compared to its heterogeneous condition in the day-time, due to convection-currents rising from the heated sands.

A large number of instances might be cited, and we should find that a clear homogeneous air transmits sounds readily, while an atmosphere broken by alternating convection-currents of warm and cold air is a very poor vehicle for sound. The explanation of this is not difficult. The original ray of sound, striking upon the first current of air, is partially reflected and partially transmitted.

The loss of the reflected portion causes a decrease in the intensity of sound. The transmitted portion, striking upon a second current, is likewise divided, and its transmitted portion continues to be so divided as many times as there are variations in the density of the air. Its reflected portion, as well as that of all the succeeding reflections, instead of being wholly lost, is interrupted in its backward course by the first current of air, and reflected along the path of the primary wave, but following it at an interval of time, depending upon the thickness of the current of air. Each reflection being thus again and again divided and reflected, we have, following close upon the primary wave, a multitude of secondary waves, which, falling later and later upon the ear, greatly mask the distinctness of the original sound, and give rise to indistinctness and confusion.

It is evident, then, that in order to procure the proper propagation of sound, one must do away with these air-currents. It must be remembered, however, that, when large numbers of people are crowded into halls, the air within is usually subjected to very considerable disturbances in order to obtain even indifferent ventilation. Registers, sprinkled here and there over the floor, send up their currents of hot and cold air. Opened windows or other cold-air ventilators send in their currents of cold air. If these currents could be made visible to the eye, as they can be detected by proper apparatus, we should see

that hot and cold currents do not readily mix, but fill the whole auditorium with alternations, continually varying in temperature and therefore in density and relative motion.

The proper solution of the problem is to admit the air in large volume, and at the proper temperature, at one side of the auditorium, carry it bodily across the room in one large mass as nearly as may be without break of homogeneity, and exhaust it at the other side. Or it may be introduced through a perforated floor and rise to be exhausted at the roof. This plan has been tried with success; the air, being first brought to the proper temperature in the basement, passes up through myriads of gimlet-holes, and is exhausted at the ceiling by means of numerous openings connected with a high chimney or other means of producing an exhaust.

An example of the first method is shown in the Baltimore Academy of Music, where the author was able to make some experiments to determine how far acoustic properties were actually dependent upon the condition of the air. The ventilation of the house is arranged as follows: The whole supply of fresh air is admitted at the back of the stage, is then warmed, then crosses the stage horizontally, passes through the proscenium, and then, somewhat diagonally toward the roof, across the auditorium, in one grand volume and with gentle motion, so as to almost entirely prevent the formation of minor air-currents. It is exhausted partially by an outlet in the roof, and partly by numerous registers in the ceilings of the galleries. From this central outlet and from the large flues of the registers, the air passes into the ventilating tower over the great chandelier, which supplies, in its heat, a part of the motive power of the circulation. It is further expelled from the tower by means of properly constructed ventilators. The acoustic properties of this house are universally agreed to be very superior.

The experiment made by the author consisted in stationing observers in various parts of the house while the performance was going on, with directions to note, at intervals during the evening, the readiness with which they could hear what was said on the stage. The observers were ignorant of the experiment to be tried. Observers A and B were stationed in the first, and C and D in the second balcony, from 8 to 10 one evening, when Neilson was playing "Rosalind." At 8.50 the ventilators were closed, so as to interrupt the normal circulation of air; and the doors into the lobbies, and thence into the street, were thrown open, that counter-currents might be established. At 9.20 the doors were closed, and the ventilators set right. The testimony of the observers was:

A (first balcony).—8 to nearly 9, good; for about half an hour, bad; afterward much better.

B (first balcony).—8 to 9, good; 9 to 9.30, bad; 9.30 to 10, good. Strong current of air felt from door a little before 9.

C (second balcony).—8 to 8.50, good; 8.50 to 9.20, bad; 9.20 to 10, good.

D (second balcony).—8 to about 9, good; 9 to 9.20, bad; 9.20 to 10, good.

An examination of the foregoing data can leave very little doubt that the condition of the air within an auditorium exercises a very considerable influence upon the facility and accuracy with which sound is conveyed.

The Academy of Music, in Baltimore, is an example of how a desirable condition of the air may be obtained. It must not be supposed, however, that acoustic success depends entirely upon the condition of the air. In fact, the condition of the air is a matter quite secondary to that which next comes up for discussion—the material and arrangement of the walls.

It is not uncommon to find churches or halls built nearly square, with a speaker's desk at one end, and a bare wall of stone covered with plaster opposite. If one goes into such a room when it is empty and speaks from the desk, he notices a loud and disagreeable reverberation following each syllable, which, if the room be large enough, comes back to him as a distinct echo. When the room is filled with people, this resonance or echo will considerably decrease; but, in such a room as we have described, it will not by any means disappear.

If now we choose a similar room, but with walls sheathed up with thin boarding or a thin layer of plaster laid on to light laths and having a free air-space behind, we shall, in all probability, find that, when this room is filled with people, the echo or reverberation will have almost if not quite disappeared. This is a comparison that the author has often made, and it gives the cue to the whole art of choosing the materials of which the walls are to be built. They must be built of such material and arranged in such way that they shall *absorb* and not *reflect* sound-waves falling upon them.

When the speaker utters his first syllable, the sound goes out in straight lines from his mouth to all parts of the house. So much of it as goes directly to the ears of the audience is effective, but all the other rays of sound ought to be as completely as possible absorbed and destroyed, else they will be reflected from the walls and ceiling back to the audience; and, arriving at their ears somewhat later than the direct sound, will give rise to the confusion or echo whose apparent effect is to bridge each syllable of the speaker over into the next, and so cause apparent indistinctness of articulation.

The presence of an audience in a room causes the absorption of such words as would otherwise be reflected from the floor, and thence to the walls, and so back and forth. But it is out of the question to cover the walls and ceiling with an audience. The absorption of the sound is, however, sometimes effected by draping heavily with cloths; but it has been found by experiment that there are other materials,

more conveniently handled, which answer the purpose much better. A sheathing of thin pine-wood, lightly suspended, particularly if there be a large and free air-space behind it, will absorb sound very completely.

There is a very great difference in the absorptive power of different wall materials for sound. Walls of stone and brick absorb hardly any of the sound that falls upon them, but reflect it nearly all; while walls of thin and dry pine-wood absorb a very much larger proportion and reflect comparatively very little. In order to determine the absorptive power of different wall materials for sound, the author has made bold to extend the general principle in radiant energy, that "bodies which give out rays most readily when excited absorb them most readily when exposed to their action," to such rays as we have in sound. Suspecting from analogy that this principle might be true for sound-waves, he has proved by experiment that this is, at least in a general way, the case, and has then devised the following method of measurement:

If a tuning-fork be set in vibration and held against a wall, it will communicate its vibrations to the wall and the wall will give out a sound, which sound will be feeble or intense just in the same proportion that its capacity to absorb sounds falling upon it is feeble or intense. In this way the absorptive power of different wall materials has been measured, and a few of the results are arranged in the order of this power in the following table:

1. Thin and dry pine sheathing, lightly supported or in panels.
2. Corrugated iron.
3. Heavy wood paneling.
4. Thin, dry, and hard plaster on light laths lightly suspended.
5. Heavy plastering on laths lightly supported or attached to wooden walls.
6. Heavy plaster on laths closely fitted to brick or stone walls.
7. Thin brick walls.
8. Thin brick walls covered with plaster directly laid on.
9. Thick brick walls.
10. Marble and other stone walls.

A comparison of this table with results actually obtained in churches in which these different wall materials are used has amply proved their correctness.

There is one fact of considerable practical value that seems especially worthy of attention. Corrugated iron, we see, has a very good absorptive power for sound, while it is durable, safe from fire, and can be easily worked into any ornamental forms desired. It seems, therefore, peculiarly fitted for the lining up of an auditorium. Bethany Church, on Franklin Square, Baltimore, is built entirely of this material, and is a decided acoustic success. We need, however, not only to attend to the material of the walls, but to their arrangement as well.

While a plain blank wall opposite the speaker will throw back a strong reverberation, if this wall be broken up by recesses, or spaced with pilasters, or if a gallery be extended across it, the reverberation will be much less.

The lining of the walls should, if possible, be placed at a considerable distance from the main wall, and supported by it so as to allow as free vibration as possible. Thus when other considerations require that the walls of a building shall be of stone or brick, the acoustic qualities may be recovered by lining up with thin pine, corrugated iron, or a thin coating of plaster on light laths, and suspending this lining as lightly as possible and at a considerable distance from the solid wall. The arrangement of walls in panels is a very advantageous one, as each panel may be so constructed as to be easily set in vibration. Perhaps the ideal arrangement would be an auditorium with brick walls, within which is a shell made up of thin wooden panels, and placed at such a distance from the solid walls that the passage-ways to the entrances on the floor and various galleries may be placed between.

In this connection it becomes necessary to discuss the proper shape to be given to an auditorium. A good way to arrive at this is to consider first an audience in the open air on a calm day. The open air on a quiet day, when the atmosphere is not disturbed by convection-currents, is probably the best possible place for speaking to a large number of people. Wesley is said to have preached successfully to twenty thousand people gathered together in a natural amphitheatre formed by the hills, and on a day when the atmosphere was at rest.

Let us take a small platform arranged for an open-air speaker, and notice how an audience will form itself about it. If the audience is large and each person anxious to hear, we shall find that the outline of the crowd will be that of a section cut through an egg, with the speaker placed at the focus of the smaller end. As in an auditorium we trust to the natural diffusion of sound to absorb the stray rays, we should evidently adopt this same ovate section for the outline of the floor.

But, when we come to consider further that it is desirable to place each member of the audience so that he can see the speaker, and so that the speaker's voice may come directly to him, we see that we conform still further to the egg-shape, for, in order that we may do this, the floor must curve upward as it recedes from the speaker, and the galleries form only a continuation of this curve. To that we may say that the proper shape of an auditorium is in general that of an egg-shell, the speaker being at the focus of the smaller end and the audience being seated over the lower half, while the upper half forms the vaulted roof. Like an egg-shell, we have seen that the walls should be thin and capable of absorbing, as fully as possible, all the stray rays of sound. While the egg-shape is the ideal, other considerations fre-

quently require considerable departures, but it will generally be found that rooms constructed on this plan, if the materials of the walls and the condition of the contained air be secured, are acoustically good.

The Greek and Roman amphitheatres, having the audiences arranged in semicircles, each circle rising above the one in front of it, and having the auditorium either open at the top or covered with awnings so that the waste sound might easily escape at the top or be absorbed by the audience around the sides, were crude approaches to this plan. The modern theatres, in which the floor slopes upward as it recedes from the stage, and in which the balconies are placed one above the other and are of horseshoe form, conform still more closely to it.

Other considerations frequently demand that music-halls and churches shall be square or oblong in shape, and it must not be supposed that acoustic success can not here be obtained. But, in these forms, great care must be taken to avoid large reflecting surfaces, and, by means of paneling or other devices, to absorb fully the waste sound.

We have now examined the two important features on which acoustic success depends. The atmosphere must be in such condition as to best allow the natural diffusion of sound; and, further, the walls must be of such material, and so arranged, as to absorb as fully as possible the waste sound. It now remains for us to look at some of the minor points which contribute to acoustic success.

There is one danger to which buildings having a vaulted roof are peculiarly liable, and that is, that the roof, if constructed of proper curvature and of non-absorbing material, is apt to act as a great concave mirror to gather up waste rays of sound and reflect them back to a focus somewhere in the audience, and so produces a loud and disagreeable echo. The architect can not exercise too great care in selecting absorbing materials, and in so arranging them as to prevent this possibility. A change in curvature, or breaking by transverse arches, will often do this. This focus would be a small area in case of a dome; but, in case of an arched roof running from front to rear, it would be a straight line.

It often happens that churches constructed without regard to acoustic principles are found, when completed, to possess this fault in a striking degree. The only complete remedy in such cases is to entirely replace the ceiling. It may, however, often be largely alleviated by placing the pulpit in a different position, as near one corner or against the wall half-way down one side. Sometimes the fault may be largely remedied by using a reflector to throw the sound out toward the audience and prevent its going up toward the roof.

Reflectors, or sounding-boards, should be used only with judicious care. Their object is not, like a concave mirror, to gather the rays of sound and throw them out to a focus in the audience. When so constructed they have been found to do more harm than good, especially

when the focus is so distant that a strong echo is returned from the opposite wall. Their object is rather to control such rays of sound as would otherwise go up to the roof and be retained as a disagreeable echo. A perfectly flat surface placed over the pulpit and not too far from the speaker's head, will often do this; but it is better to have the wall back of the pulpit gradually curve forward until it completely overhangs the speaker's head. The speaker must be near to this wall, so that the direct and reflected sounds may be as nearly as possible identical.

There is a belief, prevalent among some architects, that a hall, in order to be acoustically good, must have its length, breadth, and height in harmonic proportion. There seems to be no good foundation for this belief, and the author, after careful experimental inquiry, has failed to find that this is the case.

It frequently happens that, in a building in which there is considerable resonance, the speaker, by timing his syllables so that the resonance of one shall have disappeared before the next is uttered, may make himself understood to a large audience with comparative ease. This is recognized by most public speakers, and it is not uncommon to hear them speak of the "key-note" of any particular hall.

The act of striking the "key-note" consists not so much in pitching the voice at any particular key as in carefully timing the rate at which the syllables succeed each other.

PROGRESS OF THE GERM THEORY OF DISEASE.*

By JOHN TYNDALL, F.R.S., LL.D. (M.D., TÜBINGEN).

THE virtual triumph of the antiseptic system of surgery, based as that system is on the recognition of *living contagia* as the agents of putrefaction, is of good augury as regards the receptivity of the public mind to new views respecting the nature of contagia generally.

To the credit of English surgeons it stands recorded that, guided by their practical sagacity, they had adopted in their hospitals measures of amelioration which reduced, almost to a minimum, the rate of mortality arising from the "mortification" of wounds. They had discovered the evils incident to "dirt"; and, by keeping dirt far away from them, they had saved innumerable lives, which would undoubtedly have succumbed under conditions prevalent in many of the hospitals of Continental Europe.

In thus acting, English surgeons were, for the most part, "wiser than they knew." Their knowledge, however momentous in its prac-

* Introductory Note reprinted from Professor Tyndall's "Essays on the Floating Matter of the Air, in Relation to Putrefaction and Infection."

tical applications, was still empirical knowledge. That dirt was fatal they had discovered; but why it was fatal few of them knew. At this point Lister came forward with a scientific principle which rendered all plain. Dirt was fatal, not as dirt, but because it contained living germs which, as Schwann was the first to prove, are the cause of putrefaction. Lister extended the generalization of Schwann from dead matter to living matter, and by this apparently simple step revolutionized the art of surgery. He changed it, in fact, from an art into a science.

"Listerism" is sometimes spoken of as if it merely consisted in the application of carbolic-acid spray; but no man of any breadth of vision will regard the subject thus. The antiseptic system had been enunciated, expounded, and illustrated, prior to the introduction of the spray. The spray is a mere offshoot of the system—elegant and effective it is true, but still a matter of detail. In company with my excellent friend Mr. John Simon, I once visited St. Bartholomew's Hospital, and became acquainted, in its wards, with the practice of the late Mr. Callender. The antiseptic system was there as stringently applied as at King's College. Immediately before his departure to America I spoke to Mr. Callender on this subject; and he then told me expressly that his aim and hope had been, not to introduce a new principle, but to simplify the methods of Lister. And yet Mr. Callender's practice is sometimes spoken of as if it were, in principle, different from that of his eminent contemporary.

It is interesting, and indeed pathetic, to observe how long a discovery of priceless value to humanity may be hidden away, or rather lie openly revealed, before the final and apparently obvious step is taken toward its practical application. In 1837 Schwann clearly established the connection between putrefaction and microscopic life; but thirty years had to elapse before Lister extended to wounds the researches of Schwann on dead flesh and animal infusions. Prior to Lister the possibility of some such extension had occurred to other minds. Penetrative men had seen that the germs which produce the putrefaction of meat might also act with fatal effect in the wards of a hospital.

Thus, for example, in a paper read before the British Medical Association at Cambridge in 1864, Mr. Spencer Wells pointed out that the experiments of Pasteur, then recent, had "all a very important bearing upon the development of purulent infection and the whole class of diseases most fatal in hospitals and other overcrowded places." Mr. Wells did not, as far as I know, introduce any systematic mode of combating the organisms whose power he so early recognized. But, I believe, in hardly any other department of surgery has the success of the antiseptic system been more conspicuous and complete than in that particular sphere of practice in which Mr. Wells has won so great a name.

A remark in the paper just referred to would seem to indicate that, in regard to the further possible influence of germs, the thoughts of Mr. Spencer Wells had passed beyond the bounds of pure surgical practice. "Their influence," he says, "on the propagation of epidemic and contagious diseases has yet to be made out."

This shows that at the time here referred to the germ theory, in its wider medical sense, had begun to ferment in England. Two years, indeed, prior to the above occasion, and for the use of the same Association as that addressed by Mr. Wells, the late Dr. William Budd had drawn up a series of "Suggestions toward a Scheme for the Investigation of Epidemic and Epizoötic Diseases," which strikingly illustrate the insight of a man of genius, withdrawn from the stimulus of the metropolis, and working alone, at a time when the whole medical profession in England entertained views opposed to his. Budd states in succession, and with perfect clearness, the points which he considers most worthy of the attention of the Association. He recommends inquiry as to the nature of the evidence alleged to prove the disease under investigation to be contagious or communicable. Whether such disease admits of being artificially propagated by inoculation or otherwise. Through what surface or surfaces the virus may be shown to enter the body, and to leave it, when the disease is taken in the natural way. Whether the disease is distinguished by eruptions external or internal. Whether it has a period of true incubation; and, if so, what are the length and limits of that period. Whether one attack, as in small-pox and many other contagious diseases, preserves against future attacks. Whether in the case of human disease animals as well as man are susceptible, and, if so, what animals. What is the evidence, if any, as to the particular country or region in which the disease first appeared? What are its present geographical limits? Whether there is any evidence of its modern or recent introduction into countries previously exempt. How far any such disease may have been prevented from invading new countries, or from spreading from any particular center, by measures directed against contagion. Above all, to determine what is the nature, and what the true value, of the evidence supposed to show that the specific poison of a contagious disease may originate spontaneously, or be generated *de novo*. "What we most want to know," adds Budd, "in regard to this whole group of diseases is, *where and how the specific poisons which cause them breed and multiply*."

Budd's own relation to the question here raised was distinct, and, under the circumstances, impressive. "After giving many years of time and thought to an examination of the evidence bearing on this question," he comes to the conclusion that "there is no proof whatever" that the poisons of specific contagious diseases ever originate spontaneously. "That the evidence on which the contrary conclusion is founded is negative only; that evidence of precisely the same order,

only to all appearance still more cogent, would prove animals and plants, even of large species, to originate spontaneously; that this evidence is therefore of no weight; and, lastly, that all the really important facts point the other way, and tend to prove that these poisons (to use a term which is probably provisional only), like animals and plants, however they may have once originated, are only propagated now by the law of continuous succession."

The word "poisons," here provisionally employed, was a concession on Budd's part to his weaker brethren; for he, without a shade of doubt, considered the poison to be a real living *seed*. There was, I believe, but one physician of eminence in England who, at the time here referred to, shared this conviction, and who imparted to Budd the incalculable force derived from the approbation and encouragement of a wise and celebrated man. It gives me singular pleasure to write down here the name of the venerable Sir Thomas Watson, who lent to William Budd unfailing countenance and support, and who has lived to see that the views which commended themselves to his philosophic judgment are at the present moment advancing with resistless momentum among the members of the medical profession. It was far otherwise at the time to which we here refer. "Opinions like these," said Budd, "are no doubt, at present, those of a small minority. A very large, and by far the most influential school in this country—a school which probably embraces the great majority of medical practitioners, and the whole of the 'sanitary public'—holds the exact contrary; and teaches that sundry of these poisons are constantly being generated *de novo* by the material conditions which surround us."

Budd's remark regarding the spontaneous generation of "animals and plants, even of large species," is both pregnant and pertinent. In reference to special and solitary outbreaks of contagious fever, I have frequently heard physicians of distinction affirm, without apparent misgiving, the "impossibility" of importation from without. On such occasions a reply, in the strict sense affirmed by William Budd, was always at hand; for I was able to adduce cases of solitary mushrooms, found upon out-of-the-way Alpine slopes, to which the evidence would apply with greater force than to the cases on which the physicians referred to based their conclusions. With the atmosphere as a vehicle of universal intercommunication, it is hard to see any just warrant for the reliance of medical men upon the negative evidence stigmatized by Budd as valueless. It is, however, evidence by which many physicians are still influenced, and the effects of which it will probably require a generation of doctors, brought up under other conditions of culture and of practice, to wholly sweep away.

These conditions are growing up around us, and their influence will be all-pervading before long. Never before was medicine manned and officered as it is now. To name here the workers at present engaged in the investigation of communicable diseases would be to ex-

tend beyond all reasonable limits this Introductory Note. On the old Baconian lines of observation and experiment the work is carried on. The intercommunication of scientific thought plays here a most important part. It will probably have been noticed that, while physiologists and physicians in England and elsewhere were drawing copiously from the store of facts furnished by the researches of Pasteur, that admirable investigator long kept himself clear of physiology and medicine. There is, indeed, reason to believe that he was spurred on to his most recent achievements by the papers of Burdon Sanderson, Koch, and others. The union of scientific minds is, or ought to be, organic. They are parts of the same body, in which every member, under penalty of atrophy and decay, must discharge its due share of the duty imposed upon the whole. Of this "body," a short time since, England provided one of the healthiest limbs; but round that limb legislation has lately thrown a ligature, which threatens to damage its circulation and to divert its energies into foreign channels. In observational medicine one fine piece of work may be here referred to—the masterly inquiry of Dr. Thorne Thorne into the outbreak of typhoid fever at Caterham and Redhill. Hundreds were smitten by this epidemic, and many died. The qualities of mind illustrated in Dr. Thorne's inquiry match those displayed by William Budd in his memorable investigation of a similar outbreak in Devonshire. Dr. Budd's process was centrifugal—tracing from a single case, in the village of North Tawton, the ravages of the fever far and wide. Dr. Thorne's process was centripetal—tracing the epidemic backward, from the multitude of cases first presented, to the single individual whose infected excreta, poured into the well at Caterham, were the cause of all.

The essays here presented to the reader belong to the A B C of the great subject touched upon in the foregoing Note. The two principal ones, namely, Essays II and III, were prepared for the Royal Society, and are published in the "Philosophical Transactions" for 1876 and 1877. But, though written for that learned body, I sought to render their style and logic so clear as to render them accessible to any fairly cultivated mind. The essays on "Fermentation" and "Spontaneous Generation" have already appeared elsewhere; while the first essay, on "Dust and Disease," has been for some years before the public. It may be regarded as a kind of popular introduction to the more strenuous and original labors which follow it.

The essay most likely to try the reader's patience is Number III. On the whole, however, and particularly in its bearings on the germ theory of disease, it is probably the most important of all. The difficulties which sometimes beset the experimenter in these investigations are best illustrated by this essay. It shows, to my mind in a very impressive manner, the analogy of the spread of infection among organic infusions with its mode of propagation among human beings.

The vital resistance of certain germs to heat is strikingly illustrated in the third essay, one infusion being there proved to maintain its potentiality of life intact after eight hours' continuous exposure to the temperature of boiling water. Under the plain guidance of the germ theory, it is, however, shown that an infusion of this stubborn character may be infallibly sterilized by discontinuous heating, in one hundredth part of the time requisite when the boiling is continuous. Another question, to my mind of fundamental importance, is also disposed of in Essay III, where it is shown that the germs which exhibited the foregoing resistance are neither contained in the air, nor attached to the surface of the vessel, above the liquid, but that they manifest their extraordinary vitality in the body of the liquid itself.

On public sympathy the sanitary physician has mainly to rely for support, in a country where sanitary matters are left so much in the hands of the public itself as they are in England. But sympathy without cause—that is to say, without some basis of knowledge—is hardly to be expected. It is as a contribution to such knowledge that these essays have been collected, and thrown into their present handy form.

ROYAL INSTITUTION, *August*, 1881.

A GIGANTIC FOSSIL BIRD.

BY STANISLAS MEUNIER.

THERE are really privileged persons within the scientific domain. M. Gaston Planté, whose name is associated with a most important advance in electrical knowledge, enjoyed the opportunity, in 1855, of making, in a wholly different direction, a discovery in paleontology that was of great interest. In a very curious bed of loam of the Eocene tertiary formation, called the ossiferous conglomerate of Meudon, and which has now nearly disappeared, he found a bird's tibia, which measured, though it was not whole, forty-five centimetres in length. At first sight this great bone appeared to exhibit considerable analogies with the corresponding part of the swan, and differed from it only by the presence of the subtrochlean groove, and by the relatively high situation of the osseous arch, and the outer muscular attachment. But what a contrast in the size! An idea of it may be gained from Fig. 2, A and B, which represent the tibia of the Meudon bird—to which Constant Prevost fittingly gave the name of *Gastornis* (Gaston's bird)—and the tibia of the common swan, on the same scale.

After M. Planté's discovery, a geological formation corresponding exactly with the conglomerate of Meudon was found at Reims. Quite recently, Dr. Lemoine has established the connection between the beds

of Reims and Meudon more closely by the discovery of the remains of gastornis in Champagne, from which he has constituted a new species that he calls *Gastornis Eduardsii*. The bird was not less than three metres (about ten feet) high when standing, and is shown in that position in Fig. 1. The author possesses the femur, the tibia, the tarso metatarsian, and several phalangeal bones of this bird. The pelvis is represented in his collection by an ischion and the upper extremity of the pubis. A cervical vertebra, a caudal vertebra, a fragment of the sternum, and ends of the ribs, have furnished him subjects for interesting observations. Dr. Lemoine has collected pieces of bone, which he considers half of a breast-bone and a coracoid bone. He also describes the lower end of the humerus, a radius, a metacarpian, and the terminal phalangeal of the wing. A large proportion of the bones of the head have also been found by the author during his paleontological probings, and with their aid he is able to complete the description of this remarkable ornithological type.

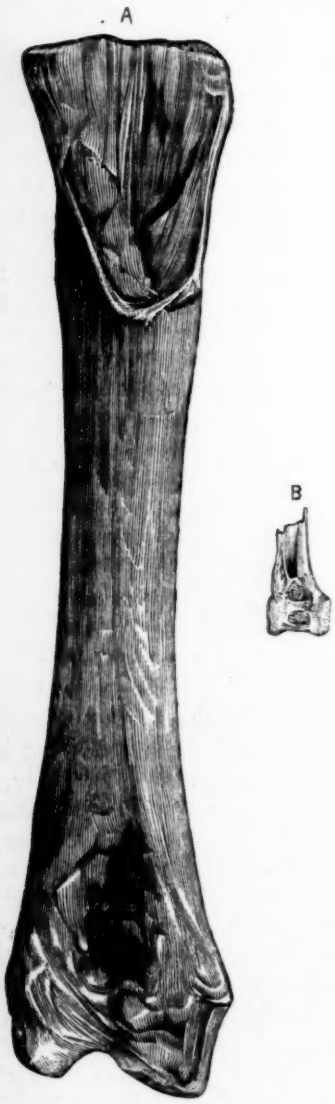


FIG. 2.—A, TIBIA OF THE GASTORNIS OF MEUDON (reduced to one third of the natural size). B, TIBIA OF THE COMMON SWAN (reduced to one third of the natural size).

All the parts of the skeleton so far discovered are represented in Fig. 1, where they have been so placed as to show the skeleton restored, in its normal position.

This richness of his material has enabled Dr. Lemoine to form very precise notions concerning the giant bird of the environs of Reims. In his opinion, the cranium must have been relatively voluminous and less disproportionate than the cranium of the ostrich. This is indicated by the quadrate bone, a part of the orbitary cavity, and almost the whole of the base of the cranium, in which the occipital condyle, the sub-condylian furrow, the basilar tuberosities, the

sphenoidal escutcheon, and the basipterygoid apophyses with their faces well accentuated, are exhibited. According to Mr. Huxley, this

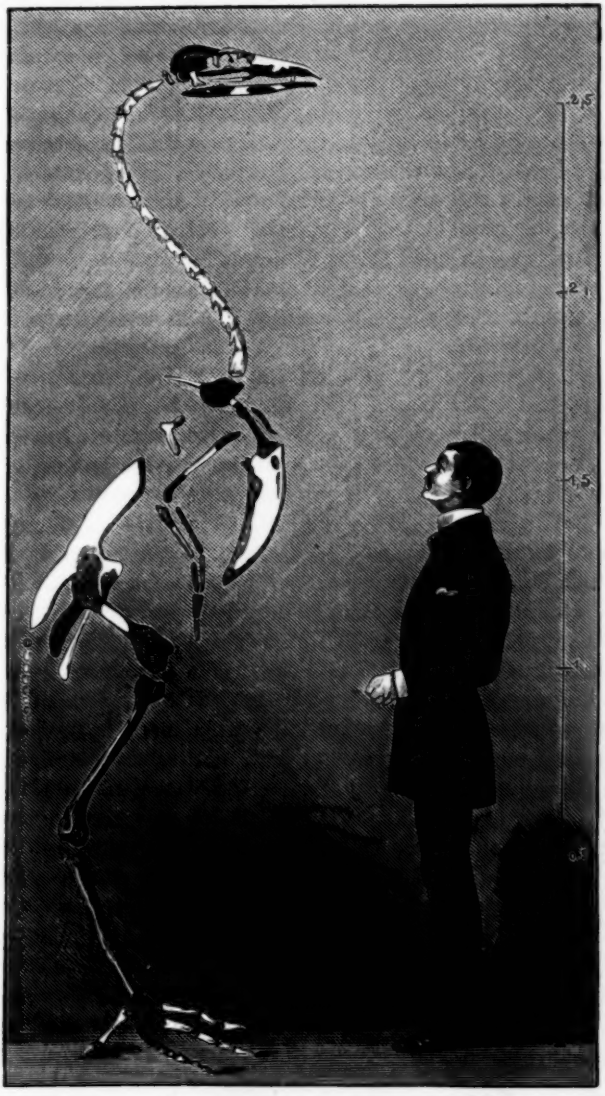


FIG. 1.—RESTORATION OF THE SKELETON OF GASTORNIS EDUARDSII, AN EOCENE BIRD, THREE METRES (or about ten feet) HIGH.

character occurs now with several birds—divers, ducks, and hens—and with several lacertians and ophidians.

The upper mandible, which was found almost entire, is very remarkable for a series of false alveoles, reminding one of the atrophied

alveoles of reptiles, and which probably corresponded, not with true teeth, but with thickenings of the horn of the bill. The bill also, toward its anterior third, seems to have represented a real tooth, but a tooth of a bony nature and of continuous substance with the bill itself. This mode of dentition had been previously observed by Richard Owen in the *Odontopteryx toliapica.*

The lower mandible is marked by its terminal extremity, which seems to have been slender, and by its hinder half presenting faintly-accentuated muscular attachments.

A part of the sternum does not permit us to say whether that portion of the skeleton had a keel. The shoulder seems to have been composed of a quite short breast-bone with a wide posterior articular surface, of a coracoid bone and of a scapulum, the group isolated and quite different from the single bone of the ostrich. The humerus is, like all the other bones of the wing, more voluminous than in the ostrich. The cubitus rather recalls the shape of that bone in ordinary birds, and bears marks indicatory of feathers. The radius was thin, the metacarpians appear to have been independent, offering a characteristic of great value, for it occurs only in two other orders. The iliac bone, very distinct, is remarkable for the sloping character of its posterior border. It is very difficult in the face of such characteristics to fix the true affinities of the gastornis. MM. Hebert, Ed. Lartet, and R. Owen, have expressed opinions on this point, and the latter is inclined to refer the fossil bird to the order of the waders, and more especially to the rails. M. Alphonse Milne-Edwards is of a different opinion, and is rather disposed, on the ground of a variety of osteological traits, to classify the gastornis with the ducks. But he is prompt to recognize that the Eocene animal offers peculiarities so different from anything shown in living nature that it is impossible to place the gastornis in any of the established natural groups. Another gastornis has been found at Reims, which Dr. Lemoine has described under the name of *Gastornis minor;* and the author has besides found the remains of two entirely different genera of birds. —*Translated from La Nature.*

THE BOOK-MEN.

By the late Hon. T. WHARTON COLLENS.

WHAT a vast difference there is between us and our ancestors who lived three thousand years ago! What savages they were! What a polished people are we! Surrounded by all the glories and lights, blessings and hopes of civilization, we can hardly realize the fact that we are the descendants of men who roamed in

forests and deserts, of men as ignorant, superstitious, wild, and brutal as the Comanche Indians. Such, nevertheless, is the fact; and the question naturally arises: How, through the ages, have our ancestors been able to overcome their abject condition, and rise to the heights of knowledge and art, to survey an immense horizon of truth, and use the magical bounties of invention? Did the light break upon us all at once; did we get all the superior advantages of science and art we now enjoy from a single hand or from one inspiration, or was the process not only slow and gradual, but difficult and terrible? To what or to whom do we owe this great change, this wonderful transformation of the mind, manners, and labors of the human race?

We answer at once: The progress of man from the savage to the civilized state of society and to its functions and uses was indeed slow and arduous, and is due to the studies of solitary, thinking book-men, careful theorists, or inquisitive philosophers, who, in each generation, and one after the other, have promulgated the result of their meditations.

Understand us—we mean what we say: we say *book-men*, we say *theorists;* and, if humor prompts, it may add contemptuous epithets to the terms. We may say, if we choose, *mere* book-men, *mad* theorists, or *dreamy* philosophers, and still the proposition would be true.

To demonstrate this truth we might begin with primeval man, go through ancient history, tracing the march of mind from the mythic Hermes of Egypt, the Pythagoras of Greece, the Zoroaster of Persia, to the grand display of civilization exhibited by the Roman Empire under Aurelius Antoninus, or under Constantine the Great, and thence follow the current in all its vicissitudes down to the present age. But the limits of a single article preclude so extended a review of human progress. Hence, we are compelled to select, if possible, a period of history within which a fair illustration of the march of mind may be found (leaving out former and subsequent ages), to test other periods by the same laws of development. Let us, therefore, begin in the middle of the middle ages, that is to say, in the year 800 after Christ, and finish with the discovery of America, in the fifteenth century. From this first point our premises will be apparent. At the last point our conclusion will be reached; and then all the consequences, as applicable to modern times, will show themselves as clearly as the landscape in the light of day.

In the year 800 after Christ, what was the state of Europe? The Goths, the Vandals, the Franks, the Huns, the Normans, the Turks, and other barbarian hordes, had invaded and overthrown the Roman Empire, and had established various kingdoms upon its ruins. These hordes of savages had destroyed, not only all the works of civilization, but civilization itself. Ignorant as they were of everything that distinguishes and elevates human nature, they broke up the schools, ruined the monuments, abolished arts and manufactures, prevented commerce,

and reduced the conquered nations to their own condition, inaugurating in the completest manner the reign of brute-force and mental darkness. If they afterward espoused Christianity, they molded it to their own savage superstition, till at last naught was left of the divine dispensation but its name, to cover the most degrading idolatry and demonism. At the time we begin our specific examination we find that, in the then so-called Christian nations—

1. There existed no science worthy of the name, no schools whatever. Reading, writing, and ciphering, were separate and distinct trades. The masses, the nobility, the poor and the rich, were wholly unacquainted with the mysteries of the alphabet and the pen. A few men, known as *clerks*, who generally belonged to the priesthood, monopolized them as a special class of artists. They taught their business only to their seminarists, apprentices; and beyond themselves and their few pupils no one knew how to read and write, nor was it expected of the generality, any more than it would be nowadays, that everybody should be a shoemaker or a lawyer. Kings did not even know how to sign their names, so that when they wanted to subscribe to a written contract, law, or treaty, which some clerk had drawn up for them, they would smear their right hand with ink, and slap it down upon the parchment saying, "Witness my hand." At a later date, some genius devised the substitute of the seal, which was impressed instead of the hand, but oftener besides the hand. Every gentleman had a seal with a peculiar device thereon. Hence the sacramental words now in use, "Witness my hand and seal," affixed to modern deeds, serve at least the purpose of reminding us of the ignorance of the middle ages.

In fact, in those days a nobleman considered it below his dignity to have any knowledge of letters. This was left to persons of inferior rank. The use of arms, horsemanship, and war, were the sole avocation of the lords of the land. As all authority, and indeed safety, depended upon force and success in battle, skill at arms was necessarily the genteelest of the arts. The nobility knew no other; and the workmen they admired the most were those who forged their uncouth armor, ungainly shields, and clumsy swords.

Society was divided into orders: at the top were the prelates and priesthood, the kings and nobles; at the bottom the serfs who were the bulk of the people; and intermediate were a few free workmen and burgesses who enjoyed a sort of *quasi* exemption from personal servitude, but were subject to the despotic rule of the king and lords.

All persons were also unmitigated believers in magic, sorcery, witchcraft, enchantments, amulets, astrology, evil-eye, conjuration, fascination, divination, fetichism, charms, evocation of ghosts, specters and devils, talismans, incantations, fortune-telling, palmistry, cabalistic arts, spells, divining-rods, bargains with the occult powers, and the

like. Even in our time vestiges of the like belief exist among us, but then it was universal and denied by none, whether prince, priest, or populace. There is no parallel to this state of things in modern times, except in the interior towns of Africa.

It was then universally conceded that the nobles were men of a superior race; that their blood was different and purer than that of other men. All the land belonged to them. No one doubted their title. The population of every barony considered the baron as their rightful master, holding his authority from God himself. It was next to sacrilege to disobey him. Yet these barons were brutal, extortionate, and cruel. They were constantly at war with each other, and therefore lived in fortified castles, whence they now and then sallied to levy contributions among their own serfs, rob passengers and caravans on the highway, or plunder and burn the property or massacre the people of neighboring fiefs. They had the right of life and death over their vassals. These could not marry or travel without their permission. The maidens of the baronies were obliged to gratify the lusts of the baron whenever he took a fancy to any of them; and this, so far from being considered as an act of outrageous despotism, was generally accepted as an honor conferred. No Turkish pasha or Russian boiar holds now greater power than the feudal lords possessed and abused during the middle ages. They exacted and took the first, the largest, and the best products of the labor of the people; and none (not even those who were the victims of unscrupulous tithes, tribute, and pillage) ever suspected that the nobles exceeded their divine and rightful privileges. The people, when robbed, or put to the rack, might think their lord was a hard and cruel master; but his right to do as he pleased was to every mind unquestionable.

The laws which then existed (if indeed the name of law could be justly applied to such an ordination of society) were only such as were calculated to maintain the power and fortune of the tyrants we have just described. Murder was punished only when the culprit was a villain, or a man of inferior rank to that of his victim; and then the punishment was graded, so that the murder of a noble or priest by a villain or inferior was avenged by the most revolting and agonizing tortures and death, while, if on the contrary the victim was a villain and the homicide a nobleman, a few pence was the price of blood. Trials there were none worthy of the name. They tested the guilt or innocence of those who were suspected of offenses by various superstitious practices, such for instance as making the supposed offender walk over red-hot plowshares. If he got burned he was guilty, if he passed over unscathed he was innocent. The favorite mode of deciding causes before the courts was the trial by battle. The parties were made to fight it out, but not always with equal arms. The villains were permitted only to wield the club, while the gentry entered the lists sword in hand, clothed in armor and on horseback.

The result of the combat was religiously believed to be "the judgment of God" between the parties.

We have said that in those ages no science existed. Let us add that it was then universally taken for certain truth that the earth was flat; that the skies were a dome of hard adamant, which inclosed and covered the world like the walls and roof of a building; that the stars were occult beings having good or evil influences over men; that the winds and the floods, the rain and the crops were either special dispensations of Providence, independent of any original design or law, or were, when unfavorable, the act of evil spirits or magical operations. The monuments of Roman architecture were allowed to go to ruin. The art of building had been almost forgotten, and was limited to the erection of rough and uncouth fortresses and walls suited to keep men and horsemen at bay. These were usually located on the tops of almost inaccessible rocks. The people lived in huts; they ate with their hands; food was cooked without pots or kettles, on the embers, or roasted on spits. Candles were unknown, stockings were unknown, clothing was made of dressed skins, and, though some woven fabrics were made by means of hand-looms, they were so inferior that the ordinary stuffs worn by the people of the present day would have been then considered as luxurious finery fit for a king to wear.

We forgot also to mention, in relation to the trial by battle, that the lawyers of those days did not gain their suits by means of evidence, authorities quoted out of books, and speeches or arguments addressed to the courts; but the lawyers were men-at-arms, expert in the use of the sword, the lance, the mace, and the *bâton;* and the parties, when they were able, would hire them to fight out the case in the arena as gladiators. Thus the case would be decided in favor of him whose lawyer beat, or cut down, or unhorsed his adversary's lawyer. Those were indeed the days when might was right.

Our object in giving this sketch of the state of civilization in the eighth and ninth centuries is, to contrast the condition of society then with what it is now, and to inquire how mankind could emerge from that order of things to the present stage of human progress. By what means were barbarism, universal ignorance, and superstition to be overcome? From whom was the first light to come? Who was to take the first step toward a better order or higher knowledge?

The impediments were of the most formidable character. Everybody was ignorant except the few *clerks*, or clergymen, we have mentioned, and even the range of their knowledge, beyond theology, was very limited. All around them was darkness, and naught indicated even a gleam of light or liberty.

By whom or when was the first step taken? By the very clerks or book-men we have mentioned, during the reign of Charlemagne in France, and that of Alfred in England. Long had they labored in the solitude of their cloisters to enlarge the scope of their learning. As-

siduously had they multiplied copies of precious manuscripts and of their own works. Zealously had they striven to find laymen willing to purchase and study those works and listen to their instructions. At last they persuaded Charlemagne to establish a school in Paris, and Alfred to found a university at Oxford, in order to educate aspirants for the priesthood and form doctors of theology. Nothing was thought of but to cultivate the kind and extent of learning then existing. It was natural to procure for these schools copies of all the books then to be found. Few, indeed, were these—as brief sketches of Latin grammar, a few Latin vocabularies, a meager treatise on arithmetic and geometry, and a stray copy of the philosophical work by Porphyry, and another by Boetius. The rest was all Christian theology and philosophy, such as the works of St. Augustine and other fathers, besides the Bible and the canons of the Church. The *savant* chosen for Paris was the monk Alcuin, and the scholar selected for Oxford was another monk, Grimbaldus.

The deed was done. A school was established. Men were offered a great opportunity of becoming book-worms, and consequently to think and theorize. The result was inevitable. To meditate, they had to exercise their reasoning faculty, while they studied the philosophy they found in the few books they had, and pondered over theology, theology and ancient philosophy as harmonized with dogma.

One of the teachers who succeeded Alcuin was a doctor of philosophy named John Scotus Erigenus, an Irishman by birth. He wrote philosophical treatises in which a new question was raised. This question was, whether an abstract term or a word, such, for instance, as the word "*humanity*," represented a real being; an essence in nature; a real and single thing existing independent of any individual. Not whether there were many individual men included by a process of thought under a general name, but whether that general name "humanity" was not the name of a *reality*, antecedent in creation and in time to the existence of any individual—antecedent to Adam himself.

Vain as this question would seem, it raised a great debate among the clerks and doctors. Soon parties were formed among them, *pro* and *con*. The one party got the name of Realists, the other that of Nominalists. Minds became excited, curiosity was aroused. In order to prove one opinion or the other, information was sought in every direction. Every scrap which could be found of Plato's and Aristotle's works was rescued from oblivion, and quoted as authority by one or the other side. Other ancient books were disinterred. The *savants* began to investigate natural phenomena, and, above all, to closely scrutinize man himself, physically and intellectually.

Though the question in debate might appear at this day quite frivolous and easily answered, yet in those times it was necessary as a first step in the progress of getting rid of the fundamental errors and

prejudices prevalent even among the *savants*. We must not lose sight of the mental condition of all men in those times. If we keep this in view, we shall, instead of despising the men who first put the question just stated, wonder how at that stage of intellectual progress it could have suggested itself to any mind. Certain it is that the most learned (so small was their amount of science, and so peculiar were the settled opinions of their age) were not ready to discuss other subjects.

They soon brought their discussions before their pupils, and from among these the debate found its way into society: kings, nobles, and burgesses talked about it, and as a consequence talked about the points of knowledge necessary to solve the question. This was a slow operation indeed. It took eight centuries before the controversy was settled.

Yet, in time, hundreds of other questions grew out of this single one, and it became necessary to settle all the minor objections and issues before the main one could be concluded upon. What is soul? what is mind? what is reason? what is feeling? what is sensation? what is knowledge? what is man and his destiny? what is revelation in contradistinction to science? how far can science go without requiring the aid of revelation? is man a free agent? are all men of the same species? what are the laws of thought?—in one word, what was true or not true in everything then generally held to be true?

We are far from wishing it to be understood that all these questions were immediately suggested or started; but the book-men (as their sphere of thought became more and more enlarged) by the sharp contradiction of one another, found it necessary to suggest and discuss them all. They did so boldly and conscientiously, in their contestations. They did so, though many among them were, for the anti-Christian opinions they advanced, condemned as heretics.

But we are too hasty. We must endeavor to show the different steps of this evolution, and the main instrumentality of the book-men and the theorists in every advance that was made.

In the course of the reign of Charlemagne, the doctors of philosophy composed a calendar, and proposed the months as we have them now. This calendar they formed by means of their studies of such ancient writings of the Greeks and Romans as they had been able to procure.

They prevailed upon Charlemagne to establish this calendar by law. By doing this, Charlemagne got all the credit of the work itself; but to a certainty he was incapable of performing it. Individually, he was an ignorant man; but he thirsted for knowledge, glory, and power; had heard from the scholars of the ancient grandeur, monuments, and literature of Rome and Greece; and his ambition impelled him to carry into effect any suggestion of measures likely to contribute to his glory. He was devout, and sought also the glory of God.

Hence he encouraged education, for he found it furnished men capable of serving him effectually in all his aspirations. But who could give education? None but the clerks or book-men, who were then the only men of science.

Passing beyond this reign, we see the effects of this policy gradually developing themselves. During the tenth century, the arithmetical figures we now use to write down numbers were first introduced into Europe. Previously the Roman letters I, V, X, L, C, etc., had been employed to express numeric quantities. The advantage of the *new* method we can all appreciate, for it is the method we all use at present. But who first introduced and taught this improvement in arithmetical notation, with all the facilities it affords for the calculations? We owe the importation to the book-men who traveled to acquire knowledge from the Arabs who had conquered Spain, and whose schools at Cordova had acquired great celebrity. Thus we see the advance of science was from one set of book-men to another set of book-men, and from their schools to the people.

In this and the preceding century too, we find that it had become a common practice for the doctors of philosophy and theology to challenge each other to *public* debates; and that it became fashionable for the gentry to be present at these intellectual duels, where thought met thought in a struggle to convince of truths or convict of error.

From theologians arose the most distinguished philosophers of the times. We could, in our advanced state of knowledge, consider the scientific opinions they advanced as unworthy of our serious consideration; but then they were of the utmost importance, in this, that they were incitements to thought and to further investigation. This was the main thing in an age of intellectual obscurity, to bring forth more and more light from the first sparks of truth. The mind once awakened, curiosity and reflection once aroused, a process of development of right reason was inaugurated, which in time spread itself from the mind of man over all nature.

This takes place in the midst of the first Crusades, by which hundreds of thousands were led to perish disastrously; but restless and curious philosophers followed in the wake of war and rapine, and hovered around the armies to bring back from the East all the science they could gather. We often read of the improvement in science the West of Europe derived from the Crusades; but the story is always told so as to leave the impression that the plunder the mind brought back from Constantinople, Antioch, Jerusalem, and Alexandria, was gathered there by the boorish soldiers and their captains. A moment's thought will, however, set us right on this point. Science could only be gathered by men already partially acquainted with science, by men having a taste for it, by the scholars and the book-men. To them, therefore, must we award all the praise for any scientific advantage

which Europe derived from the Crusades. The armies were intent upon booty and power; the philosophers who followed them were seeking for new truths; and the advance of knowledge that they returned with is one of the benefits the West of Europe derived from the Crusades.

Let us note some of the most important prizes they carried home. At Amalfi, a port in the southern part of Italy, a stopping-place for the Crusaders, they discovered a copy of the "Institutes and Pandects of Roman Law," a work which had been long lost to the world. From the Arabians of Spain or Alexandria they procured the works of Plato and Aristotle, as well as other learned treatises of ancient sages. These they studied and commented on with assiduity, each one according to the bent of his mind. Hence, in time we find the learned men not only becoming numerous, but divided into classes. Some follow the study of religion, humanity, and mind; others devote themselves to history, grammar, and poetry; others to law; others to mathematics and astronomy, and others to architecture. But we must keep in view that all these sciences and arts were yet in a crude state, far, far beneath what they are at this day. The book-men, the theorists, the philosophers, had centuries of research, discussion, and reflection to accomplish, and numberless labors to undergo, before producing the good harvest we are now enjoying.

Thus, in the thirteenth century the book-men and their disciples, the lawyers, politicians, poets, painters, masons, astronomers, architects, navigators, physicians, and all other seekers and distributors of knowledge, had hosts of adherents among the masses. Hence, the practical results of the labors of the scholars were becoming more apparent.

In religion St. Thomas produces his "Sum of Theology," and brings the scholastic philosophy to its perfection. In politics, the yeomanry of England, instigated by Archbishop Langton, a book-man, demand and obtain Magna Charta—that is to say, no taxes without representation, trial by jury, *habeas corpus*, and no taxes without the consent of Parliament; while in Florence a democratic constitution is established by the people. In science, the labors of the alchemists and astrologers are progressing toward the first positive dawn of chemistry and astronomy; and Roger Bacon, the first of the great prophets of natural science, reveals some of the most important secrets of chemistry. Roger Bacon, the first of the natural philosophers, who was he? History answers—a book-man, a monk, a solitary student of the works of his predecessors in philosophy and theology. In the arts, Gothic architecture raises a worthy tribute to Heaven. We also find that in this century navigation begins to improve and commerce to be developed, particularly in England and in Italy; and the learned take advantage of the facilities thus afforded to undertake voyages in search of geographical and other knowledge. Among the rest, Marco Polo, a student of languages, travels throughout Asia, finds his way even to

China and Japan (a most wonderful feat in those days), and, on his return, writes an account of his travels; and his book, at a later day, serves (among other things) to induce the discovery of America by Columbus.

We now enter the *fourteenth* century, and amid the many practical consequences of the dissemination of knowledge from its original source, the book-men and philosophers, we might, unless we consider the necessity of the case, lose sight of the starting-point. In Spain, Alfonso the Wise gives his people the laws of the Seven Partides, compiled by philosophical jurisconsults from the Roman law. In France, the States-General, or Grand Parliament, is convoked by Philip le Bel, and, after him, Louis X makes the Parliament a permanent institution for the sanction of all laws. By-and-by the serfs and peasantry acquire their freedom and gain many valuable rights—not, however, without insurrection and bloodshed. Marcel in Paris and the Jacquerie in the provinces strike for liberty. In England the Commons assert their privileges: no money to government without their consent; the concurrence of the Commons with the Lords necessary for all laws; and the right of inquiry and impeachment by the Commons established. In Switzerland, William Tell leads his countrymen to victory and national independence and republican institutions. In Italy, the mariner's compass is invented by Gioja de Amalfi. Dante, Boccaccio, and Petrarch, those first lights of the dawn of polite literature, compose their beautiful romances and poems. In Germany clocks are invented, and Schwartz first puts gunpowder, invented by Roger Bacon, to practical use, and some scientific mechanic builds the first paper-mill. Previously manuscripts were all written on parchment. These were magnificent results, taking place in the midst of terrible persecution; but we understand it all when we know that in spite of every obstacle and opposition the book-men had, in this and the preceding centuries, unceasingly labored amid the capricious favors and disfavors of princes and kings to establish libraries, schools, and universities everywhere. They succeeded admirably, and every generation saw the increase of the number of those to whom the benefits of education had been communicated. Notwithstanding the fears of despots, the trial by ordeal began to fall into disrepute, the influence of the principles of the laws of ancient Rome as Christianized by Justinian was felt.

At last we reach the glorious fifteenth century, ever memorable for the invention of printing and the discovery of America. Why was printing invented? Because the demand for books had directed inventive genius to seek a substitute for the laborious and costly process of copying. Guttenberg, the inventor, was himself a lover of books and a scientific mechanic. Why was America discovered? Because schools of mathematics, astronomy, and navigation had been established at Genoa, in one of which Columbus was educated. Thence,

and in subsequent life, he derived the benefits of the labors of Lorenzo of Pisa, who had introduced algebra into the universities of Europe; and of Müller and Boehm, who had, by their geometrical researches and theories, demonstrated the rotundity of the earth. With this knowledge, confirmed by observation during his early life as a navigator, and the works of Marco Polo, Columbus projected the voyage which resulted in the discovery of the Western Continent. But printing and the rotundity of the earth were not the only consequences of the studies of book-men in the fifteenth century. We have already mentioned algebra, and have time only to state that the establishment of the first bank at Genoa, the Hanseatic League, the voyage of Vasco de Gama around the Cape of Good Hope, the first working of coal-mines at Newcastle, Norwich, the first drama, the final systematization of musical notation, all took place in the fifteenth century. We should also have shown how the study of æsthetical principles in this and the preceding century, by the societies and guilds of masons and architects, endowed the world with great painters and architects, and sculptors—Benvenuto, Raphael, Angelo, Titian, and many more who have left behind them imperishable monuments of their studies and genius.

Need we look back to recapitulate and confirm the fact that the highest source, continuous movers and central custodians of the studies which caused these great events were book-men, school-men, and theologists? Let us rather look forward into succeeding centuries, and merely mention the names of Erasmus, Thomas More, Francis Bacon, Descartes, Tycho Brahe, Kepler, Galileo, Newton, Dalton, Lavoisier, Shakespeare, Harvey. But no! the names of the studious thinkers who from their cabinets and laboratories have revolutionized the world, and to whom we owe the grand and beautiful civilization and works—arts, machines, products, conveniences, political science, liberty, commerce, etc., which we now enjoy, would take hours to enumerate. There is not a development of science or art that can not be traced back to the "*eureka*" of some solitary, plodding book-man.

ABOUT ELEPHANTS.

By Dr. ANDREW WILSON, F. R. S. E.

THE interest which attaches to the modern representatives of the mammoth host is by no means limited to the zoölogical world, but extends throughout all classes of society, who find something to wonder at even in the huge proportions and ungainly ways of the elephant family. A remarkably limited family circle is that which includes the elephants as its typical representatives. The past history of the race, like that of not a few other groups of animals and plants, is exactly the converse of its present-day phases, as regards numerical

strength at least. As the existing pearly nautilus is the sole survivor of the immense hordes of four-gilled and shelled cuttle-fishes which swarmed in the primitive seas and oceans of our earth, or as the few living "lampshells," or *Brachiopods*, represent in themselves the fullness of a life that crowded the Silurian seas, so the two existing species of elephants with which we are familiar to-day stand forth among quadrupeds as the representatives of a comparatively plentiful past population of these mammalian giants. The causes which have depopulated the earth of its elephantine tenants may be alluded to hereafter; but it is evident that neither size nor strength avails against the operation of those physical environments which so powerfully affect the ways and destinies of man and monad alike. One highly important feature of elephant organization may, however, be noted even in these preliminary details respecting the modern scarcity of elephantine species, namely, that the slow increase of the race, and, as compared with other animals at least, the resulting paucity of numbers, must have had their own share as conditions affecting the existence of these huge animals. The elephants are, of all known animals, the slowest to increase in numbers. At the earliest, the female elephant does not become a parent until the age of thirty years, and only six young are capable of being produced during the parental period, which appears to cease at ninety years of age; the average duration of elephant-life being presumed to be about a hundred years. But it is most interesting, as well as important, in view of any speculation on the increase of species and on the question of competition among the races of animal life, to reflect that, given favorable conditions of existence, such as a sufficiency of food, a freedom from disease and from the attack of enemies, and the elephant race, slow of increase as it is, would come in a few thousand years to stock the entire world with its huge representatives. On the data afforded by the foregoing details of the age at which these animals produce young, and of their parental period, it is easy to calculate that in from seven hundred and forty to seven hundred and fifty years, nineteen million elephants would remain to represent a natural population. If such a contingency awaits even a slowly increasing race such as the elephants unquestionably are, the powerful nature of the adverse conditions which have ousted their kith and kin from a place among living quadrupeds can readily be conceived. In the face of such facts, the contention that the "struggle for existence," in lopping off the weak and allowing the strong to survive, accomplishes in its way an actual good becomes clear. And the important biological lesson is also enforced, that there is a tolerably deep meed of philosophy involved in the Laureate's pertinent remark concerning the "secret meaning" of the deeds of Nature, through

> "finding that of fifty seeds
> She often brings but one to bear."

Reference has already been made to the paucity of existing species of elephants, only two distinct species being included in the lists of modern naturalists. These are the African elephant (*Loxodon* [or *Elephas*] *Africanus*) and the Indian elephant (*Elephas Indicus*). But the elephantine race is not without its variations and digressions from the ordinary type. We discover that among the elephants of each species "varieties" are by no means uncommon. These varieties appear as the progeny of ordinary animals. Thus the Sumatran elephant and that of Ceylon are regarded as constituting a distinct species, one authority (Schlegel), indeed, affixing to it the distinctive appellation of *Elephas Sumatrensis*. The balance of zoölogical opinion, however, is in favor of the Ceylon form being simply a "variety" of the Indian species; in other words, the differences between these two forms are not accounted of sufficient merit to elevate the former to the rank of a distinct animal unit. The famous "white elephants," whose existence has given origin to the proverbial expression concerning the disadvantage of unwieldy possessions, have a veritable existence. In Siam, as is well known, these animals are regarded with the utmost reverence, and are held in sacred estimation and kept in royal state by sovereign command. They are to be regarded, however, merely as an albino or colorless "variety" of the Indian species. Their production depends, like that of albinos or white varieties of birds or other animals, on some undetermined conditions affecting development. We occasionally find white varieties of birds—even including that paradoxical anomaly, a white blackbird—and albino cats are as familiar objects as are albino rabbits and white mice. Darwin remarks on the fact that albinism is very susceptible of transmission to offspring, and it is so even in the human race. It is not known whether the white elephants exhibit any special peculiarity of structure or life; but the interesting correlation has been observed that almost all white cats which possess blue eyes are deaf. The nature and origin of this association of characters are unknown, but the occurrence of such apparently unconnected states serves to remind us that great as yet are the mysteries which environ the becoming of the living worlds.

The characters of the Indian and African elephants, respectively, are by no means difficult to bear in mind. The Indian elephant (Fig. 1, 2) has a concave or hollow forehead, and the ears are of relatively moderate size. The eye is exceptionally small, while there are four nails or hoofs on the hind-feet, the number of toes on each foot being five in all elephants. The color of the Indian species is, moreover, a pale brown, and is of a lighter hue than that of the African species; and, while the former has "tusks" in the males alone, the latter possesses tusks in both sexes. The African elephant (Fig. 1, 1) has a rounded skull and a convex forehead, and the ears are of very large size. It possesses only three nails on the hind-feet, and four hoofs on

the front toes. Certain important differences, to be presently noted, also exist between the teeth of these species.

The limits of size of the two species of elephants appear to have afforded subject-matter for considerable discussion. The average height of the male Indian elephant is from eight to ten feet, and that

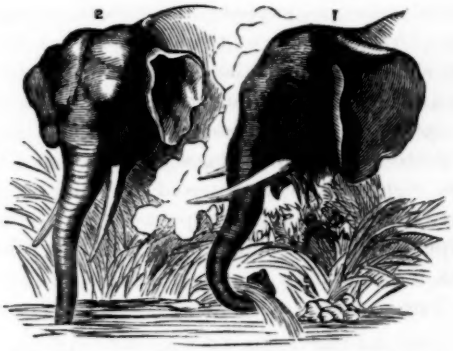


FIG. 1.—HEADS OF (1) AFRICAN AND (2) INDIAN ELEPHANTS.

of the females from seven to eight feet. The African species, according to the most generally recorded testimony, attains a larger size than its Indian neighbor. Sir Emerson Tennent, quoting a source of error in the measurement of elephants, gives the remarks of a writer who says :

"Elephants were measured formerly, and even now, by natives, as to their height, by throwing a rope over them, the ends brought to the ground on each side, and half the length taken as the true height. Hence the origin of elephants fifteen and sixteen feet high. A rod held at right angles to the measuring rod, and parallel to the ground, will rarely give more than ten feet, the majority being under nine."

As regards the number of elephants captured annually, a recent return gives us five hundred and three as captured in the three years ending 1880, in the forests of Assam, by the Indian Government.

There exist a few points in the special anatomy of the elephants of which it may be permissible to treat briefly, and, of these points, the skeleton presents several for examination. First in interest, perhaps, comes the enormous size of the skull, and the modifications wherewith this huge mass of bone is rendered relatively light and more easily supported on the spine. The skull of the elephant is unquestionably large, even when considered in relation to the huge body of which it forms such an important part; but, when the skull is seen in section, we discover that, instead of presenting us with a solid mass of bone, its walls are hollowed out in a remarkable fashion, so as to materially reduce its weight. It is evident that a demand exists in these animals for a skull of great strength, which not only shall be

equal to the task of giving origin to muscles of power sufficient for the animal's movements, but which may also adequately support the great "tusks." And Nature has succeeded accordingly, by a most interesting modification, in uniting size and strength to a minimum of weight.

A very short but strong neck and powerful bony processes borne on the joints thereof serve as support and holdfasts respectively for the huge cranium. In other parts of the skeleton, such as in the shape and form of the shoulder-blade, the elephants resemble the rodent quadrupeds, such as the hares, rabbits, rats, beavers, etc.; and it has long been a notable fact of elephantine anatomy that this resemblance is by no means limited even to the bones. But a somewhat ludicrous peculiarity of the elephants, readily noted by the observer, and one referred to by both classic and modern poets, is their awkward gait; and this again depends upon a readily understood anatomical modification. It is such a peculiarity that is referred to in "Troilus and Cressida," in the lines—

> "The elephant hath joints, but none for courtesy,
> His legs are legs for necessity, not for flexure."

And again the phrase—

> "I hope you are no elephant, you have joints,"

evidently refers to the curious and ungainly movements of these quadrupeds. The explanation of the elephantine gait rests primarily with the length of the thigh-bone, and with the facts that this bone is very long and lies perpendicularly to the line or axis of the spine, the thigh not forming an acute angle with the spine, as in other quadrupeds. Thus, the "ham" of the animal stretches half-way down the thigh, and, when the animal walks, the bend of the knee or leg at the latter point imparts a decided clumsiness to the gait. The great body rests, not so much upon the toes as upon the great pads which unite the toes, and which in fact constitute a broad, flat sole behind these members. Similar pads in the rhinoceros and hippopotamus support the weight of the body. No collar-bones are developed in the elephant race—a fact which, of course, bears a relation to the absence of those movements, such as climbing, etc., in which these bones play an important part, as serving to fix the limb employed. The brain of the elephant reveals certain points of anatomical interest. For example, the lesser brain or "cerebellum" is not covered by the brain proper or "cerebrum"; but the surface of the latter is deeply convoluted or folded. The existence of deep brain-convolutions in man is believed to be associated with a high measure of intellectual power, and the elephants do not seem to belie the statement, as applied to lower life, when their sagacity is taken into consideration. The proportion borne by the weight of the brain to that of the body has always formed an interesting topic of physiological nature. As a matter of fact, great varia-

tions exist when the ratio of brain to body is examined in different animals. Thus in man, as is the case with lower animals, the ratio diminishes with increasing weight and height. In lean persons the ratio is often as 1 : 22 to 27, and in stout persons as 1 : 50 to 100. In the Greenland whale the ratio is given as 1 to 3,000; in the ox as 1 to 160; in the horse as 1 to 400; in the dog as 1 to 305; in the elephant as 1 to 500; in the chimpanzee as 1 to 50; and in man as 1 to 36.

The absolute weight of brain in an elephant which was seven and a half feet high, and eight and a half feet in length from forehead to tail, was nine pounds. The brain of an Indian elephant was found to weigh ten pounds; and Sir Astley Cooper gives the weight of the brain of another specimen as eight pounds, one ounce, and two grains; while that of an African elephant seventeen years old was found by Perrault to weigh nine pounds.

The muscular system of the elephant necessarily partakes of the massive character adapted for the work of moving and transporting the huge frame. But the anatomy of the "proboscis" or "trunk" constitutes in itself a special topic of interest, and one, moreover, which gives to the proboscidian race one of its most notable characteristics. The "trunk" is, of course, the elongated nose of the elephant. It is perforated by the nostrils which open at its tip, and above the apertures is a curious finger-like process, which, when opposed to a small projection somewhat resembling a thumb in function, constitutes a veritable hand, and is utilized by the animal in almost every detail of its life. With the exception of the snout of the tapirs, the trunk of the elephant has not even a distant parallel in the animal series. Its muscles form two sets of fibers, one set of which compressing its substance also extends its length, while the second set shortens the organ and enables it to bend freely in any direction. When we add to the possession of this extreme muscularity a high degree of sensitiveness, the proboscis of these animals may be regarded in the light of one of the most useful as well as most interesting features of their organization. Its use is not limited to the prehension of food (Fig. 2, 1, 2), however, or even to the additional function of an organ of touch. Occasionally, water is drawn up into the trunk, and is then squirted over the body as from a flexible hose (Fig. 2, 3), thus serving as a kind of shower-bath apparatus; and stories have been recorded wherein such a use of the proboscis has played a prominent part in the act of elephantine revenge on some over-bold or offending human.

The teeth of the elephantine race form a highly characteristic feature of their anatomy. In the mouth of a higher quadruped, such as man, the bat, or ape, no less than four kinds of teeth are represented. These are the front teeth, or incisors, the "eye-teeth," or canines, the premolars, and the molars, or "grinders."

In the elephants, only two kinds of teeth are represented, these be-

ing the incisors, or front teeth, and the molars, or grinders; while the front teeth themselves only exist in the upper jaw. The incisors grow from "permanent pulps," and hence they increase during the whole life of the animal, or nearly so. A large pair of tusks may weigh from one hundred and fifty to two hundred pounds, and as regards struct-

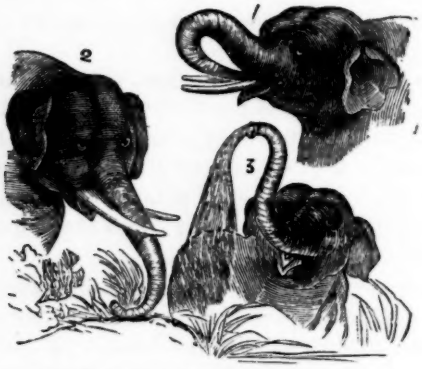


FIG. 2.—VARIOUS USES OF THE PROBOSCIS.

ure they are found to consist of dentine, or "ivory," and of "cement"; while the enamel, which forms such a characteristic feature of ordinary teeth, may or may not be represented. The tusks vary, according to Darwin, "in the different species or races according to sex, nearly as do the horns of ruminants. In India and Malacca, the males alone are provided with well-developed tusks. The elephant of Ceylon," adds Mr. Darwin, "is considered by most naturalists as a distinct race; there, 'not one in a hundred is found with tusks, the few that possess them being exclusively males.' The African elephant is undoubtedly distinct, and the female has large, well-developed tusks, though not so large as those of the male." The molars, or grinding-teeth, exhibit an equally curious structure. In the life-time of an elephant twenty-four molar teeth are developed in all, six on each side of each jaw. But, at any one time in the life of the animal, not more than two of these teeth are to be seen in each side of the jaw. A curious succession of these molars takes place in the elephants, for they are found to move from behind forward, the teeth in use being gradually ousted from their place by their successors as the former are worn away. Thus the whole set of molars in due time moves forward in the jaw and each successive tooth is, as a rule, larger than its predecessor. In structure, the molars of the elephant are highly peculiar, each exhibiting the appearance rather of a compound than of a single tooth. Each tooth is built up of a series of plates set perpendicularly in the tooth, and consisting of ivory, or "dentine," covered by enamel, while "cement" fills up the interspaces between the plates. As the tooth wears in its work, the enamel comes to project above the surface of the tooth,

and a characteristic pattern is thus developed on the surface of the molars of each species of living elephant. Thus, in the Indian elephant, the molars exhibit a series of cross-ridges, which are more numerous than those of the African species, while in the latter form the enamel plates form a distinctly lozenge-shaped pattern. It sometimes happens that in elephants kept in captivity the succession of the teeth is disarranged, from the fact that the molars are not worn away fast enough, and the succeeding teeth are displaced, thereby causing deformity of the jaws.

The elephants were included in the older systems of classification in a somewhat heterogeneous group of quadrupeds named the *Pachydermata*. That this order—now abolished and divided to form several new groups—was motley enough in its representation is readily seen, when we discover that the rhinoceroses, hippopotami, and other forms were included within its limits along with the elephants themselves. The technical name "Pachydermata" related to the thick skin which invests the bodies of the animals just mentioned, and in the elephants this characteristic is, of course, extremely well represented. The thick skin hangs in folds on the body, while the typical hair-covering which, by natural right, all quadrupeds possess, is but sparsely developed. It would seem, however, that the young elephant possesses a much more profuse covering of hairs than the adult. Such a statement is consistent with the general biological law which holds that the young form exhibits the primitive characters of the race more typically than the adult. In this view of matters the young elephant is nearer the type of its ancestors than the adult; and in the young whales the same remark holds good; since the youthful cetaceans may possess a sparse covering of hairs, such as the adults do not exhibit.

Speaking of the comparative hairlessness of the elephant and rhinoceros, Mr. Darwin remarks that, "as certain extinct species (e. g., mammoth) which formerly lived under an Arctic climate, were covered with hair, it would almost appear as if the existing species of both genera had lost their hairy covering from exposure to heat. This appears the more probable, as the elephants in India which live on elevated and cool districts are more hairy than those on the lowlands."

The social history and psychology of the elephant race form of themselves topics wide enough to fill a volume. From the earliest times, these animals have been enlisted by man in the service of war, or as beasts of burden, as aids in the chase, or even in the brutal and demoralizing sports of the ancient arena. The value of ivory in the earliest ages must have given rise to elephant-hunting as a source of gain and profit; and the inroads of man upon the species have naturally caused not merely a limitation in the numbers of these animals, but have likewise served to modify, in a very marked fashion, their geographical distribution. But the utility of these great animals to man depends as much upon their docility and tractable nature as

upon their manufacture of ivory. Probably there is no more sagacious animal than a well-trained elephant, and the development of such high instincts as these animals exhibit may form an additional illustration of the marked influence of association with man in inducing the growth of intelligence and reasoning powers in the animal creation. No one may doubt that the dog, for instance, has benefited to a marked degree from such association with human surroundings, and that the comparatively low mental powers of many other animals are susceptible of higher development through domestication is an idea fully supported by all that is known of instances where a wild race, or individual animal of wild habits, has been brought in contact with man. The "learned pigs" and tame hares are cases in point; and the relatively low mental powers of many of the apes may be largely attributed to that want of interest in "poor relations" with which humanity, as a body, views the quadrumanous tribes.

The records of popular natural history teem with examples of the sagacity of elephants, a mental quality which, it may be added, is likely to owe much to the relatively long life and corresponding opportunities of acquiring experience which these animals possess; while it has been also remarked that, as the elephant, unlike the dog, rarely breeds in captivity, and as each individual elephant has to acquire, independently of heredity, its own knowledge of the world and of man, so to speak, these great animals present infinitely more remarkable examples of animal sagacity than the dog. One specially interesting feature of elephant-life consists in the aid given by the domesticated elephant to man in the capture of the wild species. The fact of these animals entering into an offensive and, from its very nature, an intelligent alliance with man, against their own race, may be regarded either as illustrating the desire to benefit the race by conferring upon them the blessings of civilized life and employment, or as exemplifying a process of demoralization and treacherous development which might afford an argument against the universally beneficial effects of domestication of the animal form. Nor is the probem rendered any the less attractive to the metaphysician and moralist, when it is discovered that it is through the caresses and blandishments of the false females that the wild elephants are tempted into the snare: the parallelism between the experiences of lower and higher life being too obvious in this instance to escape remark.

Probably no animal exhibits a greater knowledge or instinctive apprehension of danger than an elephant. Instances are numerous, for example, when an elephant has refused to cross a bridge esteemed safe by his human guides, but which has collapsed with the animal's weight, when, goaded and tortured to proceed, he has advanced in despair, only to find himself immersed in the water below. But cases are also recorded in which the danger experienced by the elephant itself has apparently not rendered it insensible to the safety of its keeper. "The

elephant," says Darwin, "is very faithful to his driver or keeper, and probably considers him as the leader of the herd. Dr. Hooker informs me that an elephant which he was riding in India became so deeply bogged that he remained stuck fast until the next day, when he was extricated by men with ropes. Under such circumstances elephants will seize with their trunks any object, dead or alive, to place under their knees to prevent their sinking deeper in the mud; and the driver was dreadfully afraid lest the animal should have seized Dr. Hooker and crushed him to death. But the driver himself, as Dr. Hooker was assured, ran no risk. This forbearance, under an emergency so dreadful for a heavy animal, is a wonderful proof of noble fidelity." Swainson gives a description of the sagacity of an elephant under such circumstances which is worth quoting in the present instance: "The cylindrical form of an elephant's leg—which is nearly of equal thickness—causes the animal to sink very deep in heavy ground, especially in the muddy banks of small rivers. When thus situated, the animal will endeavor to lie on his side, so as to avoid sinking deeper, and, for this purpose, will avail himself of every means to obtain relief. The usual mode of extricating him is much the same as when he is pitted; that is, by supplying him liberally with straw, boughs, grass, etc.; these materials being thrown to the distressed animal, he forces them down with his trunk, till they are lodged under his fore-feet in sufficient quantity to resist his pressure. Having thus formed a sufficient basis for exertion, the sagacious animal next proceeds to thrust other bundles under his belly, and as far back under his flanks as he can reach; when such a basis is formed as may be, in his mind, proper to proceed upon, he throws his whole weight forward, and gets his hind-feet gradually upon the straw, etc. Being once confirmed on a solid footing, he will next place the succeeding bundles before him, pressing them well with his trunk, so as to form a causeway by which to reach the firm ground. . . . He will not bear any weight, definitely, until, by trial both with his trunk and the next foot that is to be planted, he has completely satisfied himself of the firmness of the ground he is to tread upon. . . . The anxiety of the animal when bemired forms a strong contrast with the pleasure he so strongly evinces on arriving at *terra firma*." Such an account becomes extremely interesting, as convincing us that much, if not all, of the sagacity which is called forth by such circumstances must be inherent and original, as opposed to that gained by experience. It can not be supposed that the accident described can form such a frequent experience of elephant-existence in a wild state as to constitute a certain basis for acquired knowledge of what to do in the exigency. On the contrary, it seems more reasonable to suppose that the inherent and intuitive sagacity of the animal is simply called forth by the threatened danger, and that such an exigency brings into play mental acts analogous to those whereby, through mechanical and similar contrivances to those employed by the

elephant, man might rescue himself or his property from immersion in the swamps.

The memory of elephants is of a highly remarkable nature, both as to its duration and in its operation as enabling the animal to recognize friends and foes. I am fortunate in being able to place on record an instance of elephant memory of a very interesting kind, and one which serves to show in a highly typical manner the remembrance by these animals of kindness, and also of the reverse treatment. In 1874 Wombwell's menagerie visited Tenbury, in Gloucestershire, and on that occasion the female elephant, "Lizzie" by name, drank a large quantity of cold water when heated after a long walk—the animal, as a consequence, being attacked with severe internal spasms. A local chemist, a Mr. Turley, being called in as medical adviser, succeeded in relieving the elephant's pain, the treatment including the application of a very large blister to the side. The menagerie in due course went its way; but, in May, 1879, it again visited Tenbury, and, as Mr. Turley stood at his shop-door watching the zoölogical procession pass down the street, the elephant stepped out of the ranks, crossed from one side of the street to the other, and, having advanced to Mr. Turley, placed her trunk round his hand and held it firmly, at the same time making, as Mr. Turley informs me, a peculiar grunting noise, as if by way of welcome. Thus it was clear that, after an interval of five years, "Lizzie" had recognized an old friend in Mr. Turley, and that, moreover, she remembered him with a sense of gratitude for his successful endeavors to relieve the pain from which she had suffered. At night Mr. Turley visited the menagerie, when the elephant again made every demonstration of joy, and embraced him with her trunk. She drew Mr. Turley's attention particularly to the side whereon the blister had been applied, thus showing that all the circumstances of five years previous were fresh in her memory. Observing that in 1881 the menagerie had again visited Tenbury, I wrote to Mr. Turley, inquiring if "Lizzie" had again recognized her old friend. That gentleman replied, his letter bearing date May, 1881, that she had again recognized him, beginning to "trumpet" whenever she beheld Mr. Turley among the spectators in the menagerie. On his speaking to his patient, she placed her trunk round his legs and lifted him from the ground, but in the gentlest manner possible. On Mr. Turley proceeding to examine one of her hind-legs, which had been under treatment, the elephant kept holding one of her fore-legs toward him in such a fashion as to draw his attention to the limb. As Mr. Turley, however, had had no concern with the fore-leg, he was puzzled to account for the animal's movement; but the keeper explained that the fore-leg in question had been treated by a veterinary surgeon for an injury, and that the latter had used his lancet to afford relief. The elephant was irritated by the operation, and expressed her resentment on again seeing the veterinary practitioner by striking at him with her trunk. The act of call-

ing Mr. Turley's attention to the fore-leg was simply an expression of admiration for the gentler treatment to which he had subjected his patient; the quieter medical treatment contrasting apparently with the rougher surgical measure to which the fore-leg had been subjected. It is thus clear not merely that the elephantine nature is endowed with an active memory, but that a lively sense of gratitude for past kindness is also represented in the list of mental attributes of this giant race.

A parallel instance of elephant memory is afforded by the case of an elephant which, having broken loose from the stables on a stormy night, escaped into the jungles. Four years thereafter, when a drove of wild elephants was captured in the "keddah," or inclosure, the keeper of the lost elephant went to inspect the new arrivals, and climbed on the railings of the "keddah" to obtain a satisfactory view of the captured animals. Having fancied that among the animals he recognized the escaped elephant—an idea ridiculed by his comrades—he called his lost charge by name. The animal at once came close to the barrier, and, on the keeper proceeding into the inclosure and commanding it to lie down, the elephant obeyed, and the man led his former charge triumphantly forth from among its wild companions. But the memory of kindnesses is equaled in the elephant by that which recalls acts of injury to remembrance. The well-known story of the Indian elephant which, on being pricked by a native tailor near whose stall it had wandered, returned and deluged the man with a shower-bath of dirty water, finds many parallels in the history of elephant character. An elephant, which was kept at Versailles by Louis XIV, was in the habit of revenging himself for affronts and injuries. A man who, feigning to throw something into his mouth, disappointed him, was beaten to the ground with the trunk and trampled upon. On a painter desiring to sketch this elephant with trunk erect and mouth open, his servant was instructed to feed the elephant for the purpose of inducing the animal to assume the desired attitude. But, the supply of food falling short and elephantine chagrin being aroused, the elephant, drawing up water into his trunk, coolly showered it down upon the unfortunate painter and his sketch, drenching the one, and rendering the other useless.

The pugnacity of the elephant is very great, and the determination with which contests are carried on between these animals is highly remarkable. Mr. Darwin, on the authority of the late Dr. Falconer, tells us that the Indian species fights in varied fashions, determined by the position and curvature of his tusks. "When they are directed forward and upward, he is able to fling a tiger to a great distance—it is said to even thirty feet; when they are short and turned downward, he endeavors suddenly to pin the tiger to the ground, and, in consequence, is dangerous to the rider, who is liable to be jerked off the howdah"—for it is on

"Elephants endorsed with towers,"

as Milton has it, that the great carnivore of India is hunted. A most remarkable trait of elephant existence, and one which parallels the proverbial "red rag" and bovine fury, is the apparent animosity of the race to white color. Sir Samuel Baker says that both the African elephant and the rhinoceros attack gray or white horses with fury. The explanation of such traits of character probably lies hidden in that philosophy of color in relation to sex and animal development which the reseaches of Darwin and others have so far unraveled.

As a final observation regarding the psychology of the elephant, Mr. Darwin's statements concerning the "weeping" of these animals may be quoted. Remarking that the Indian species is known to weep, Mr. Darwin quotes Sir Emerson Tennent, who says that some "lay motionless on the ground, with no other indication of suffering than the tears which suffused their eyes and flowed incessantly." Another elephant, "when overpowered and made fast," exhibited great grief; "his violence sank to utter prostration, and he lay on the ground, uttering choking cries, with tears trickling down his cheeks." "In the Zoölogical Gardens," says Darwin, "the keeper of the Indian elephants positively asserts that he has several times seen tears rolling down the face of the old female, when distressed by the removal of the young one." Mr. Darwin also makes the interesting observation that, when the Indian elephant "trumpets," the orbicular muscles of the eyes contract, while in the "trumpeting" of the African species these muscles do not act. Hence, as Mr. Darwin believes that in man the violent contraction of the muscles round the eyes is connected with the flow of tears, it would seem by analogy to be a legitimate inference that the Indian elephant has attained a higher stage in the expression of its emotions than its African neighbor.

The social history of the elephants includes several somewhat melancholy incidents connected with the dispatch of these animals, rendered necessary from their dangerous condition. The best known of these incidents is that connected with the death of Chunee, the Exeter Change elephant, reported in the "Times" for March 2, 1826. The account of the death of Chunee is as follows:

The elephant was a male, and had been an inmate of the Exeter Change Menagerie for seventeen years. He was brought from Bombay, where he was caught when quite young, and was supposed to be about five years old when purchased by Mr. Cross; consequently his present age is twenty-two. The effect of his unavoidable seclusion had displayed itself in strong symptoms of irritability during a certain season from the first, and these symptoms had been observed to become stronger during each succeeding year as it advanced toward maturity. The animal was altogether kept at this season very low, and also plentifully physicked, for which latter purpose no less than one hundred-weight of salts was frequently given to him at a time. Notwithstanding these precautions, the animal within the last few days had shown strong proofs of irritability, refusing the caress of his keepers and attempting to strike at them with his trunk on their approaching him, also at times rolling himself about his den and

forcibly battering its sides. About 1 P. M. he became more ungovernable than ever, and commenced battering the bars of his den with his trunk. These bars are upward of three feet in girth, and are composed of oak, strongly bound on all sides with iron, and are placed about a foot asunder. For some time they resisted the ponderous blows which he almost incessantly directed against them, but by 2 P. M. one of them was found to be started from the massive cross-beam into which it was mortised: and, as at that time the animal still continued as violent as ever, serious fear began to be entertained lest he should break out, in which event the amount of damage or loss of life which he might occasion would have been incalculable. In these circumstances, although the value of the animal was at least one thousand pounds, Mr. Cross at once determined on having him destroyed, and after some consideration it was resolved to give him some corrosive sublimate in a mess of hay. However, the animal no sooner smelled the mixture than he rejected it, and it was then determined to shoot him. Accordingly, a messenger was sent to Somerset House, where two soldiers were on guard, who, on a suitable representation being made, were allowed to go over to the menagerie, taking with them their muskets. Several rifle-guns were also obtained from different places in the neighborhood and put into the hands of such of the persons about the establishment as had courage enough to remain in the room. In this manner, in all about fourteen persons were armed, but before commencing operations it was deemed prudent to secure the front of the den, by passing cords around those bars against which the animal's violence had been principally directed. This having been done and the muskets loaded, about a third of the party advanced to the front of the den till within about five yards of the animal and discharged their pieces at the tender part of the neck below the ear, and then immediately retreated to a recess at the lower end of the room for the purpose of reloading. The animal, on finding himself wounded, uttered a loud and piercing groan, and advancing to the front of the den struck his trunk several times with all his fury against the bars, another of which he succeeded in forcing out of its place. Having thus exhausted his fury, he became quiet, upon which another detachment of the party approached his den, and, after firing upon him, retired into the recess as before; the animal on receiving the fire plunged again most violently against the front of the den, the door of which he actually lifted from off its uppermost hinges, but was prevented from getting out by the strong manner in which the ropes bound the different bars together. On his becoming more tranquil, preparations were made for firing a third volley; but no sooner were the muskets about to be leveled than the animal, as if conscious of their being the cause of his wounds and also of the vulnerable parts against which they were intended to be directed, turned sharp round and retreated into the back of the den and hid his head between his shoulders. It hence became necessary to rouse him by pricking him with spears, which being effected, the muskets were discharged at him, and, although several balls evidently took effect in the neck on this as well as on the former occasion, still he did not exhibit any signs of weakness, beyond abstaining from those violent efforts which he had previously made against the front of his den; indeed, from this time he kept almost entirely at the back of his den, and, although blood flowed profusely from the wounds he had received, he gave no other symptoms of passion or pain than an occasional groan. For about an hour and a half in this manner a continuous discharge of musketry was kept up against him, and no less than one hundred and fifty-two bullets were expended before he fell to the ground, where he lay nearly motionless, and was soon de-

spatched with a sword, which, after being secured upon the end of a rifle, was plunged into his neck. The quantity of blood that flowed was very considerable, and flooded the den to a great depth. This was the same elephant who was the *accidental* cause of its keeper's death, whose ribs it crushed four months back while in the act of turning round in its den.

After reading this account, we may well feel tempted to indorse the opinion of a correspondent of "Land and Water," who remarks that the like of it "can never occur again, thank God, in England!"

The history of the elephants would be manifestly imperfect, even when detailed in the briefest manner, without a reference to their present distribution and to the biography of the race in the past. As in the case of many other groups of animals and plants, we can only fully appreciate the modern relations of the elephants when some knowledge of their development in the geological ages has been obtained. In the eyes of the modern naturalist, the present of any living being is not merely bound up in its past development, but the existing conditions of any race become explicable in many cases only when the former range of the group in time has been ascertained. This holds especially true of the elephants; for the existing species represent the remnants of a once larger and far more extensive distribution of proboscidian life. Hence, it behooves us to make the acquaintance, firstly, of their present distribution, and secondly of their distribution and development in past ages, if we are to understand with any degree of completeness and mental satisfaction the relations of the elephantine races.

The distribution of the elephant on the earth as it now exists may be disposed of in a very few words. The Indian species occurs in Asia, from the Himalayas to Ceylon, while its range extends eastward to the Chinese borders, and southward to Sumatra and Borneo as well. The African species possesses as localized a habitat. It was Swift who, remarking on the customs of geographers in his day, said:

> "So geographers in Afric maps
> With savage pictures fill their gaps,
> And o'er unhabitable downs
> Place elephants for want of towns."

The witty dean's lines show at least that the geographers did not mistake the wide distribution of the giant animal in the Ethiopian continent. For, south of the Sahara—the territory north of which is zoölogically a part of Europe—the African elephant is everywhere found, forming one of the most characteristic features at once of the African landscape and of the Ethiopian fauna, and dividing the sovereignty of the land with the lion himself.

Turning now to the past history of the elephant race, one may primarily note the more prominent members of the group which rank among the curiosities of the geologist. First in order comes the extinct mammoth—the *Elephas primigenius* (Fig. 3) of the naturalist.

Of this huge elephant we possess considerable knowledge, inasmuch as specimens have been obtained, literally packed amid the Siberian ice, and so perfectly preserved that even the delicate tissues of the eyes could be inspected. This was the case in the famous specimen found in the frozen soil of a cliff at the mouth of the Lena in 1799. The skin of this huge elephant was then seen to be clothed with a thick coating of reddish wool interspersed with black hairs. The skeleton, removed in 1806 by Mr. Adams, and preserved in St. Petersburg, measures sixteen feet four inches in length, the height is nine feet four

FIG. 3.—SKELETON OF MAMMOTH.

inches, and the tusks measure each nine feet six inches along their curve. The mammoth's tusks appear to have had a wider curvature (Fig. 3) than those of existing elephants; and probably, like the African species, both male and female mammoths possessed these great teeth. The measurement of mammoth tusks from recent deposits in

Essex gives a length of nine feet ten inches along the outer curve, and two feet five inches in circumference at the thickest part. Another specimen weighed one hundred and sixty pounds; and a dredged specimen taken off Dungeness was eleven feet long. The mammoth's tusks have long formed articles of commerce and barter in Siberia; the ivory, as Professor Owen remarks, being "so little altered as to be fit for the purposes of manufacture." The mammoth's extensive range forms not the least noteworthy point in its history. It certainly roamed farther abroad, so far as we know, than any other elephantine form. Its remains occur in Britain and in Europe generally; they have been found on the Mediterranean coast and in Siberia; and they are met with in North America as well. In Scotland and in Ireland the mammoth was apparently less plentiful, but its remains occur in these countries, where, indeed, no other elephantine remains are found. It may be added that the molar teeth of the mammoth are by no means unlike those of the Indian elephant in the arrangement and pattern of its enamel plates.

Another extinct elephant, equally famous with the mammoth, was the *Mastodon*—a name given to these animals in allusion to the nipple-like projections seen on the surface of the molar teeth. Their remains occur in Europe, Asia, and in North and South America. In the morasses of Ohio and Kentucky, for example, whole skeletons of these interesting elephants have been discovered. The length of the mastodon in some cases exceeded sixteen feet; and the tusks have been found to measure twelve feet in length. Over a dozen species of mastodons have been described, but they agree in certain important characters which serve to distinguish them from other elephants. Thus, the roughened teeth appear to have been adapted for bruising coarse herbs and leaves—indeed, associated with mastodon remains in America collections of leaves have been found occupying the situation in which the stomach of the animal would have been situated, and thus indicating the dietary of these extinct giants. Furthermore, a most important difference between the mastodons and other elephants is found in the fact that these animals possessed two tusks springing from the lower jaw, in addition to the tusks with which, as in ordinary elephants, the upper jaw was provided. But it would seem that these lower tusks never attained a large size, while it is probable that they fell out when the animal attained the adult period of its existence.

More extraordinary still, in respect of its variations from the ordinary structure of the elephants, was the *Dinotherium* (Fig. 4), the fossil remains of which occur in Europe and in India. The skull of a dinotherium has been found to measure four feet in length, while a thigh-bone was five feet three inches long. Thus, in so far as size is concerned, the dinotherium may claim a foremost place among its elephantine cousins. But various circumstances seem to suggest that the latter animal departed from the elephant type in certain important

particulars, while some authorities have been even found to suggest that it represents a connecting link between the elephants and the sea-cow or manatee order (*Sirenia*). The tusks of dinotherium spring from the lower jaw (Fig. 4); and instead of being curved forward and upward, they bend abruptly downward and backward. The use of these tusks is extremely difficult to determine, but it has been suggested that the dinotherium was an aquatic animal, living in shallow waters, and that these huge teeth may have enabled it to root up the plants on which it fed, or have enabled it to climb, as does the living walrus, from the sea on to the river-banks.

FIG. 4.—RESTORATION OF DINOTHERIUM.

In addition to these latter elephants, which are essentially distinct from the living species, certain extinct forms may be mentioned which, in their essential characteristics, resembled existing proboscidians more or less closely. Thus, we know that elephants closely related to the Indian species existed in Asia in Miocene times, the remains of at least six species being obtained from Indian deposits of that age; and we also know that Europe boasted of elephants in that period of geology known as the "Pliocene"; for in the deposits of France and Italy, as well as in the formations of that age in Britain, elephant remains occur. Later in point of time come the curious "pygmy elephants" of Malta, whose remains exist in that island, and whereof one (*Elephas Melitensis*) attained the size of a donkey, while another (*Elephas Falconeri*) was smaller still, and averaged two and a half or three feet in height.

The geological order and the succession in time of these various elephants is important to trace; for the unraveling of so much of the past history of the elephants as is known to us depends upon the knowledge of their succession and of the periods of their appearance and extinction. If we tabulate the rocks wherewith the past of the elephants is concerned, we may render their arrangement clear thus:

TERTIARY ROCKS, including	QUATERNARY,	Recent (Soils, etc.).
		Post-Pliocene (Ice Age).
	PLIOCENE,	
	MIOCENE,	
	EOCENE,	

Thus the oldest and lowest of the Tertiary rocks—which are themselves collectively the most recently formed—is the "Eocene," and the succeeding "Miocene," "Pliocene," and "Quaternary," are given in their due order; the latter formations bringing us to the soils and surface accumulations of our own day. The "Ice Age," or "Glacial Epoch," we may also note, occurred during the Post-Pliocene period, as shown above.

Turning now to the past history of the elephants, we find the first chapter of that biography to open in the "Miocene" age. The earlier or "Eocene" period contains no elephant fossils, and it may have been that in this Eocene age, which beheld the first beginnings of nearly all the existing quadruped races, the evolution of the elephant stock from its ancestry was taking place. Leaving for the present the consideration of the probable root of the elephantine tree, we thus discover in the Miocene period the first beginnings of elephant existence. In this period the mastodons roamed over Europe and India, while in this age also the dinotheriums, with their great lower tusks, made their first appearance on the stage of time. As the geological series progressed, and as the Pliocene age succeeded the Miocene times, we discover the elephants in increasing numbers. The Miocene, with its relatively few elephantine forms, contrasts forcibly with the increase of those animals in the succeeding age. Europe and India harbor its Pliocene elephants, as we have seen; while both Europe and America in this latter age possessed the mastodons. The Post-Pliocene period, however, dawns in turn, to find the mastodons still existent in North America, but unknown in Europe; while the mammoth now appears as a representative form, along with survivals of the European elephants of the Pliocene time. The "pygmy elephants" of Malta also belong to the Post-Pliocene age.

Thus we discover that a distinct *succession of types* of elephantine forms has taken place on the earth's surface, beginning with elephants which, like the dinotherium and mastodon, differ from existent species, and ending with elephants which, like the mammoth or the European elephants of the Pliocene, more or less closely resembled the quadruped giants of to-day. It becomes interesting further to trace out the later history of the race before the bearings of these facts on the origin of the elephant race are discussed. The mammoth, for example, certainly survived the "ice-age," to the irruption of which was probably due the extinction of the other elephantine forms. We know of this survival because its remains occur in "recent" or "post-glacial" deposits. We are also certain that early man must have beheld the mammoth as a living, breathing reality, for its remains have been found associated with the rude implements of early men, and a rough portrait of the great red-haired elephant has been discovered, scratched on one of its tusks—a rude but unquestionable tribute of early art to the science of zoölogy. Its woolly hair, protecting it against

the rigors of the ice-age, may have enabled it to survive that period, which was apparently so fatal to elephant life at large.

Summing up the details we have thus collated, from the geological side, we may now face the problem of the origin of the elephant race. Not that the problem itself is fully answerable, for our knowledge of the elephant race in the past is yet of comparatively limited extent; but the main lines of the biological argument are clear enough to those who will consider, even casually, the evidence already at hand. It is thus clear that the true elephants, which belong to the Pliocene period, are ushered into existence, so to speak, by forms that are less typical elephants—mastodon and dinotherium—when judged by the standard of existent elephantine structure. There are various species of mastodons known to geologists, which exhibit a gradation in the matter of their teeth, and presumably in other structural aspects as well, toward the ordinary elephant type. As the mastodons precede the ordinary elephants in time, we shall not be deducing an unwarrantable inference if we maintain that the origin of the true elephants, both fossil and living forms, may safely be regarded as arising from the mastodon stock. The elephants of to-day are connected by links of obvious nature with the Pliocene and Post-Pliocene forms; and, when the "ice-age" cleared the earth of the vast majority of the species, the progenitors of our living elephants must have escaped destruction and have survived the cold, possibly in the regions wherein they now exist, just as the mammoth, in its turn, survived the rigors of the ice-period, through the presence of its woolly coating and its hardier constitution. There seems thus to be no special difficulty, either of purely geological or of intellectual nature, in conceiving that the elephants of to-day are simply survivals of that elephantine host, whose existence was well-nigh terminated by the "ice-age," and which left the mammoth, and the progenitors of our living elephants, to replenish the earth after a catastrophe as sweeping and fatal in its nature as any deluge.

But if the origin of the modern and later elephants may thus be accounted for, and if their geographical birthplace may be assumed to exist within the confines of the Old World, a more fundamental and anterior query may be put with reference to the origin of the mastodon stock, which we have supposed, and with reason, is the founder of the true elephant races. From what stock, in other words, did the mastodons themselves arise? The chain of organic causation, to be perfect and complete, can not assume the mysterious origin of the mastodon. That stock must, in its turn, have originated in an ancestry less like the elephants than itself. It is not improbable that the evolutionist of the future will seek and find the mastodon ancestry in the dinotherium group, or in some nearly related forms. For, as we have seen, the dinotherium exhibits a structure which appears to relate the elephants to other and lower quadrupeds, such as the sea-cows

and their neighbors. If this supposition be permissible, then a further stage still awaits our intellectual journey in the search after the origin of the elephant races. In the Eocene rocks of North America occur the fossil remains of some extinct quadrupeds, of which the *Dinoceras* is the best-known form. These animals unite in a singular fashion the characters of elephants and ordinary "hoofed" quadrupeds. While they possessed horns, they also developed tusks from the eye-teeth; and, from a survey of their complete organization, Professor Marsh tells us that the position of these unique quadrupeds is intermediate between the elephants themselves and the great order to which the hoofed quadrupeds belong. Dinoceras and its neighbors precede the dinotherium and mastodon in time, and this fact alone is important as bearing on the assumed relationship of these forms.

It may thus at present be assumed with safety that the evolution of the elephants has taken place from some ancient Eocene quadruped stock, represented by the Dinoceras group, which belongs to no one group of living quadrupeds, but is intermediate in its nature, as we have already observed. From some such stock, then, we may figure the dinotherium and mastodon races to have been in due time evolved. The New World, in this light, must have been the birthplace of the elephant hosts; for the Dinoceras and its neighbors are of North American origin; migration to the Old World having taken place by continuous land-surface then existent, and the further evolution of the living species and their fossil neighbors having occurred in the Eastern hemisphere. Thus, once again we arrive at the existing races of elephants. These are simply the survivals of an ancient line of quadrupeds, whose history is simply that of every other living being—animal or plant—a history which, like the unfolding of a flower, leads us from form to form, along pathways of variation and change, and which, at last, as the ages are born and die, evolves, from the buried and forgotten races of past monsters, the no less curious and unwieldy quadruped giants of to-day.—*Belgravia.*

THE CHEMISTRY OF SUGAR.

By Professor HARVEY W. WILEY.

THE annual consumption of sugar by the people of the United States amounts to more than forty pounds *per capitum.* This gives as a total the enormous quantity of two billion pounds per annum. The cost of this commodity may be safely placed at eight cents a pound. The total value of the sugar consumed each year, therefore, is one hundred and sixty million dollars. Sugar is a theme of general and pecuniary interest, which is a sufficient excuse for an article on its chemistry.

Sugar is a general name applied to a class of bodies composed of carbon, oxygen, and hydrogen, having a more or less sweet taste, and exercising a rotatory power on the plane of polarized light.

In chemical composition the sugars may be regarded as a combination of water with carbon, and they belong therefore to that class of bodies which are known as carbo-hydrates. Starch, wood-fiber, and various sorts of gums are bodies nearly allied in chemical composition to sugar.

Sugar is chiefly a product of vegetable growth, and is found in some part or other of a large number of substances.

Sometimes it is found in the root, as in the beet and sweet-potato. Again, it occurs in the fruit, as in the grape and water-melon. At other times it is stored in the juices of the plant, as in the maple-tree and the sugar-cane.

In whatever position it occurs, it is always diluted with water, and mixed with various gums and albuminous bodies peculiar to the plant containing it.

The manufacture and refining of sugar consist in separating it from these impurities, and evaporating the water until the crystallizing point is reached, or a sirup is produced.

I have said that sugar is of vegetable origin. This must be construed to mean the sugars of commerce and common consumption. The animal organism possesses a glycogenic function in common with plants.

The amount of sugar, however, produced by the animal organism, with the exception of that from the milk-glands, is inconsiderable in a state of health. In certain forms of disease, however, as in *diabetes mellitus*, the amount of sugar produced in the body may be immensely increased.

Sugar may also be made by chemical means from the bodies already mentioned, such as starch, cellulose, gum, etc.

In this sketch I will mention only the more important sugars. For the purposes of a popular classification the sugars may be arranged as follows:

1. Cane-sugar, or sucrose.
2. Grape-sugar, or glucose.
3. Milk-sugar, or lactose.
4. Starch-sugar, or amylose.

Cane-sugar, in a commercial sense, is by far the most important of these bodies.

It has never been formed by chemical synthesis, and the chief sources from which it is derived are the sugar-cane, the sugar-beet, and the sugar-maple. When pure it is a white crystalline body easily soluble in water and having an intensely sweet taste. The molecule of cane-sugar consists of forty-five atoms, distributed as follows, viz., twelve atoms of carbon, twenty-two of hydrogen, and eleven of oxy-

gen. By the hundred this is equal to 42·11 per cent of carbon; 51·46 per cent oxygen, and 6·43 per cent hydrogen. Its expression by symbols is $C_{12}H_{22}O_{11}$. The amounts of carbon and hydrogen in cane-sugar are determined by igniting it with oxide of copper or other substance rich in oxygen. By this process the carbon is converted into carbon dioxide (carbonic acid), and the hydrogen into water, each of which substances is easily collected and weighed.

Indeed, this process is used for estimating carbon and hydrogen in all sugars. The oxygen is usually estimated by difference.

It has thus been shown that oxygen and hydrogen exist in sugar in the exact proportions necessary to form water. A *materialistic* definition of sugar would be forty parts of fine charcoal mixed with fifty-eight parts of pure water. Yet charcoal and water mixed in the above proportions are far from being sweet; a good illustration of the difference between chemical union and mechanical mixture. Pure cane-sugar, when left to itself, has no tendency to change. When diluted with water, however, and brought in contact with a nitrogenous body it undergoes fermentation, and yields at first alcohol, carbonic dioxide, and other products, as will be shown subsequently.

Pure cane-sugar has the power of twisting the plane of polarized light to the right. For the purple ray or transition tint this torsion amounts to 73·8°, and for the monochromatic sodium-flame to 66·67°. These numbers represent its *specific rotatory power.*

I will give an explanation of what these terms and numbers signify further on. From this property the chemist is able to determine the amount of pure sugar in any sample submitted to him for examination, and containing no other optically active body. For, if, using the sodium-flame, he should find the rotation to be 33·34°, he would know at once that the sample contained only fifty per cent of sugar, and so on for other numbers. When cane-sugar is heated with an acid, or for a long time to a high temperature without one, it suffers a peculiar change which is called *inversion.* Inverted sugar has almost lost its power of crystallization, and has changed its deportment toward polarized light. It consists now of two distinct kinds of sugar, one of which turns the plane of polarized light to the left and is called *lævulose,* while the other turns it to the right and is called *dextrose.*

At ordinary temperatures, however, the lævo-rotatory power of inverted sugar is much greater than the other. This preponderance of lævo-rotatory power increases as the temperature falls, and diminishes as it rises. At 88° Cent., these two powers are equal, and the sugar exerts no influence whatever on polarized light.

These twin constituents of inverted sugar can be separated with lime, which forms with the lævulose a compound less soluble than with the dextrose, and from which the latter is separated by pressure. The lime compound is then decomposed by oxalic acid and the lævulose set free.

Honey is composed of left-handed or invert-sugar, some grape-sugar, and more or less cane-sugar. After keeping for some time the cane-sugar is all converted into the invert variety. When cane-sugar is heated to a temperature of about 200° C., it undergoes a transformation, and a part of it is changed into an aromatic substance called *caramel*. This change consists essentially in the loss of two molecules of water. Caramel is used chiefly in the manufacture of candies, for flavoring whiskies, brandies, etc.

A pleasing and instructive experiment which any one can try will show that sugar is made of charcoal and water. A strong solution of sugar is placed in a glass until the bottom is well covered. Strong sulphuric acid (oil of vitriol) is now added, and the whole stirred with a glass rod until it swells up and turns black. The sulphuric acid has a very strong liking for water, which it steals from the sugar molecules, leaving only the carbon.

Another interesting experiment is to burn the carbon in sugar with the oxygen in the chlorate of potassium, the fire being kindled with a drop of sulphuric acid. For this experiment four parts of sugar are carefully mixed in an old saucer with five parts of chlorate of potassium, and the mass then touched with a glass rod which has been dipped into strong sulphuric acid. The chemical action produced by the sulphuric acid makes heat enough to ignite the whole mass, and the carbon of the sugar is thus burned out.

Grape-sugar, as its name implies, is found in grapes and some other substances. This name is also sometimes incorrectly given to one, and often all the sugars made from starch or derived from fruits. It is dextro-gyratory, having for the sodium ray a specific rotatory power of about 52·5°. It is fermentable, and is not changed by heating with dilute acids. It crystallizes, but with less facility than cane-sugar, and is much less sweet to the taste. There are other varieties of sugar which possess the same properties as grape-sugar. To these the general name, *dextrose* or *glucose*, has been given. Any sugar, whatever be its source, which, in a dry state, has the formula $C_6H_{12}O_6$, and a specific rotatory power of 52·5° to the right, is entitled to the name *dextrose*.

Dextrose is also the final product of long-continued boiling of starch with an acid.

Starch-sugar, or amylose, is a mixture of various products, chief among which are dextrose, dextrine, and maltose.

For a full discussion of this sugar I refer to my paper in this magazine for June, 1881.

Milk-sugar, or lactose, is found in milk, and is not important commercially. It is used mostly as a vehicle for administering medicines. In composition it is identical with cane-sugar, but differs from it greatly in both chemical and physical properties.

Optically it is nearly related to dextrose, its specific rotatory power

being only a little greater. It is much less soluble and much less sweet than cane-sugar.

Both lactose and dextrose, where freshly dissolved from the crystalline state, have a rotatory power nearly double the normal. This peculiarity is called "birotation." Milk-sugar ferments when mixed with yeast, but not so readily as grape-sugar or dextrose. The fermented milk forms a mild alcoholic beverage much prized in some countries.

Most sugars readily combine with lime, and with the alkalies, and also with many of the ordinary salts. Cane-sugar especially combines easily with bases almost like an acid, forming salts which are called *sucrates.*

Many metallic compounds help the crystallization of the sugars, and such salts have been used in the refining of sugar for this purpose. Owing to the difficulty, however, of removing these compounds completely, the practice has been generally abandoned.

The action of sugars on copper compounds is of especial interest, because it is used as a means of estimating the quantity of sugar present in a substance.

Alkaline copper solutions, when heated with most sugars, have their copper reduced to the form of a suboxide (Cn_2O). Of the sugars which act in this way, I may mention grape-sugar, lactose, dextrose, and maltose. Pure cane-sugar does not act upon copper solutions until after it has been converted into invert-sugar. Dextrine or starch gum is likewise inactive. The copper solution generally employed for the estimation of sugar contains the copper in the form of a tartrate, with some sulphate of sodium and an excess of sodium hydrate in the mixture. It is called "Fehling's solution."

The specific rotatory power of a sugar is its property of twisting the plane of polarized light either to the right or left. The instrument used to determine this is called a polariscope, or saccharimeter. The instrument in more common use has an ordinary oil or gas lamp as the source of light. By quartz plates this light is modified in character so as to produce a tint most sensible to change. This is called the *transition tint,* or *teinte de passage.* It is a purplish color, which on the one side changes to blue, and on the other to a rose-red. In the last few years instruments using a monochromatic light are coming into use, and they have some advantages over the other kind. The one-color light is produced by passing the rays from a sodium-flame through a crystal of bichromate of potassium, by which a pure yellow is obtained.

The field of view in these instruments has only half its area filled by a quartz plate. When the instrument is adjusted to zero the quartz semi-disk offers no opposition to the passage of the light. Interposing, however, a tube containing a sugar solution, one half the field is darkened. The analyzer is then turned until the field is equally illuminated

again, and the angle through which it has been moved is read on a divided circle and vernier.

Since the rotation is less for the sodium-ray than for the transition tint, the two are distinguished by different symbols. For the former the symbol $[a]_D$ is used, and for the latter [a] or $[a]_j$. The one-color saccharimeter is especially to be recommended for those who may be subject to any degree of color-blindness. A discussion of the optical principles involved in circular polarization would be out of place here.

Fermentation is a peculiar decomposition which sugars suffer under the influence of a nitrogeneous germ called the "ferment."

Cane-sugar, under the influence of a mucous sporule, undergoes "mucous fermentation," and is converted into a gum and a kind of sugar called "mannite." Neither acid nor alcohol is produced by this process.

Lactic fermentation takes place under the influence of an organism called *penicilium glaucum*. The chief product of this fermentative is *lactic acid*. In the case of a dextrose it may be represented by the following equation :

Dextrose. Lactic Acid.

$$C_6H_{12}O_6 = 2\,C_3H_6O_3.$$

Milk-sugar undergoes this fermentation most readily, first absorbing a molecule of water and then breaking up into four molecules of lactic acid. If the process is allowed to go on, the lactic acid will break up into butyric acid, carbonic dioxide, and hydrogen. If the *Torula aceti* take the place of the germ named above, cane-sugar especially will yield acetic instead of lactic acid.

The *vinous* is by far the most important of the fermentations to which sugars are subjected.

Ordinary *yeast* is the nitrogenous body which seems best suited to develop this change.

Cane-sugar, before undergoing vinous fermentation, absorbs a molecule of water and is changed by an active principle of the yeast into invert-sugar. The chief products of vinous fermentation are alcohol and carbonic dioxide. Less important products are succinic acid, glycerine, cellulose, and fat.

All the sugar, with the exception of about four per cent., is converted into the two products first named. By an equation, the process may be represented as follows :

Sucrose. Water. Alcohol. Carbonic dioxide.

$$C_{12}H_{22}O_{11} + H_2O = 4\,C_2H_6O + 4\,CO_2.$$

The peculiar fungus which is most active in the vinous fermentation is *saccharomyces cerevisiæ ;* but there is much about the process which is yet obscure.

In the conversion of starch into sugar by diastase or acids, and the conversion of sugar into alcohol by fermentation, we have the *rationale* of that vast industry carried on by distillers and brewers. If the

process of vinous fermentation is continued, the alcohol is converted chiefly into acetic acid (vinegar).

Decolorization.—Even a brief account of the chemistry of sugar would not be complete without an allusion to the methods employed to remove the coloring-matters naturally present in all sugars.

Sulphurous acid is sometimes employed for bleaching, but the carbon obtained by heating blood, bones, and other animal substances in closed retorts is by far the most efficacious means of decolorizing known. The pure white sugars and light-colored sirups of commerce are decolorized with this animal char. We may say that this decolorization is effected by oxidation of the coloring-matter, and yet the phenomenon does not appear to be wholly one of oxidation. Like the process of fermentation, it is difficult to explain it in full.

The solutions of sugar of a proper degree of dilution are passed, often under pressure, through successive filters of animal charcoal until their color is fully discharged.

Since a high temperature tends both to render sugar of a deeper color, and if it be sucrose to invert it, the evaporation of the sirup is carried on in vacuum-pans, whereby it is effected much more rapidly and without impairing the power of crystallization in the finished product.

From the multitude of facts connected with the chemistry of sugar I have endeavored to select those which are most important and of most interest to the general reader. Every intelligent man can not be a specialist in every department of science, but he can easily acquire a general idea of the progress of science. It is certainly a part of a liberal education to know something of the chemistry of common things.

This country ought to make its own sugar. The sugar-fields of Louisiana, with wiser management and a more scientific agriculture, could be made to increase their yield tenfold. Along the more northern parts of the Union the climate and soil are well adapted to the culture of the sugar-beet. We should not be discouraged because a few attempts in this direction have not proved financially successful. Twenty-five years of failure in Europe have been followed by fifty years of success, until at the present time two fifths of all the cane-sugar produced in the world are obtained from the sugar-beet. Last of all, the great Indian-corn-producing area of the country is peculiarly suited to the growth of the sorghum sugar-cane, and the production of crystallized sugar from this source is no longer a mere possibility. It has already been realized. Land which will produce forty bushels of corn per acre will yield from six hundred to a thousand pounds of sugar, and nearly one hundred gallons of sirup. In another decade, instead of having to import eleven twelfths of the sugar we consume, as we do now, we may hope to produce it all.

TRANSCENDENTAL GEOMETRY.

By ALFRED C. LANE.

TRANSCENDENTAL geometry is the geometry of solids and surfaces in n-dimensional or in curved space. Exactly what surfaces and what solids is a hard question to answer, and the answer is still harder to understand. Let us, then, first find out in what way or ways the science of transcendental geometry arose.

Descartes invented a method of applying algebra to geometry by the well-known Cartesian co-ordinates. As you remember, a point in a plane is determined by two co-ordinates, x and y, for example; a point in space by three, x, y, and z. Now, the question is not unnatural, "What would x, y, z, v, determine?" The natural answer is, "A point in space of four dimensions."

Moreover, we see that, although we have no experience of space of four dimensions, we could form equations between four variables, and transform and combine them as we do in analytic geometry of three dimensions. By adopting a code of interpretation as like to our ordinary code as circumstances would permit, we could interpret the relations of our equations as geometrical relations.

But, as the idea of a fourth dimension to space is almost if not quite inconceivable, let us endeavor to render it less so if possible. Imagine a man deprived of everything but vision, in the way of sensible experience. The world to him would be two dimensional. If, then, he were taken out to drive, he would see continual changes in his plane of vision, but he would ascribe them merely to the effects of *time*. For example, were he to go through a covered bridge, his sensations might be as follows: A small dark spot, gradually enlarging till it covers the field of vision; then a small bright spot in the middle of it, which would similarly enlarge.

Now, suppose our universe sliced in two by a plane which moved along through it. Suppose sentient beings inhabited this plane. They would perceive at once two dimensions of our universe and the third as a *succession in time*. So we might suppose ourselves conscious of three dimensions of our universe, and of the fourth as the succession of things in time. Thus we might consider time as a dimension. It is so considered in the mechanical curves of position. Yet we should then have to bring in time relative to time.

We will illustrate still further by considering the theory of knots. It is evident that, so long as the line represented in the adjoined figure is kept in the plane, the knot or kink can not be got out of it. But, by turning the loop up, it can be removed at once.

The annexed knot—the type of all knots in ordinary space—can

not be undone without severing the ends. In four-dimensional space it could. By this means Zöllner interpreted some of the knot-untying performances of Slade, the American spiritualist. Let us, for example, interpret these facts, using time as fourth dimension, bringing in, of course, time relative to time. If time were a fourth dimension, parts of the state of things at different instants might be visible together. Thus we could have A, C, B, after being tied, joined to A, D, B, and then A, C, B, before being tied.

But we must remember, in passing on, that algebraic equations are capable of other than geometrical interpretations, and that their relations by themselves prove nothing in regard to real or possible relations between external facts. Moreover, the algebraic theory of dimensionality will be interpreted fully by nothing less than a space of infinite dimensionality.

We come now to the most difficult branch of the subject, that of curved surfaces and of curved space. The curvature of a plane curve at any point is the limit of the ratio of the length of the curve to the difference in direction of the initial and terminal tangents. Its differential expression is $D_s s$ or $\frac{D \times {}^2y}{[1 + (D \times y)^2]^{\frac{3}{2}}}$. To get the curvature of a curved surface at any point, we slice it up by planes normal to it at that point. On each of these planes it will describe a curve. These curves will have different curvatures at the original point. The reciprocal of the product of the greatest and least of these is called by Gauss the measure of curvature. This name he also applied to an analogous function of the co-ordinates of a point in space. The expression, for a plane curve, of the curvature is the reciprocal of the radius of the circle of closest possible contact at the point investigated. Hence, some have argued that transcendental geometry was inconsistent, in that it talked about the curvature of a space where there were not Euclidean straight lines, hence no radii, and nothing to refer the curvature to. This argument is open to other answers, but it is enough to say that the measure of curvature has no necessary connection with radii.

To return, the condition that a rigid figure can be moved about on a surface without changing its shape, or that a rigid body can be similarly moved in space, is that the measure of curvature of the surface or space is constant in value. Some one might say that, if a body is rigid, no motion can change its shape. This, however, is not true of the mathematically rigid body except under the above conditions, taking the most general definition of a rigid body.

It is assumed in Euclid that motion of a figure does not alter it. That is, if an angle, A B C, is equal to an angle B C D, it will be equal to it however it is as a whole moved or rotated. This is an assumption that the measure of curvature of the plane or space is constant. Moreover, if we assume it constantly equal to naught, the

so-called geometrical axioms that two straight lines can not inclose a surface, etc., are true. For example, a spherical surface has a constant measure of curvature not equal to zero, and positive. Since the shortest distance between two points is a straight line, let us, extending the analogy, call the shortest distance between two points of a spherical surface, *lying wholly* in that surface, a straight line of that surface. Now, as the measure of curvature of a spherical surface is constant, we can slide a figure about over the surface without altering it, as is evident at once. On a sphere, however, more than one perpendicular can be drawn on the surface from a point to a straight line, and two straight lines can inclose a surface.

In a surface whose curvature is negative, an infinite number of straight lines of the surface can be drawn through a given point which will never meet a given straight line. Such a surface would be like a spool. Some of its sections would be concave and others convex to the same point. We have analogous results in what is called curved space. These results were first suggested by Riemann, who was a pupil of Gauss.

For this mathematical treatment all that is needed is, first, algebra and the differential calculus; secondly, a method of interpreting them geometrically. We have found a code of interpretation for some algebraic equations which give geometrical results, and we apply it so far as we can to all.

So far the mathematicians might have gone without let or hindrance, and there some of them, as Boole and Grassman, stopped. But others thought they had settled whether the geometrical axioms were *a priori* truths or not. We have just worked out a system of geometry, said they, which is not, as we think, impossible, where these axioms do not hold. Therefore these axioms are the results of an experience of things as they are. If we had had a different order of things, as is possible, these axioms would not have been true nor thought of. I shall, however, try to prove that, although not thought of, they are true.

The geometrical axioms express relations; relations between what?

Geometry is a branch of mathematics. Therefore the geometrical axioms express mathematical relations. What, then, is mathematics, and with what does it deal?

Mathematics, in its widest sense, I will define as the science which treats of logical—that is necessary—relations. Between outside things there are no necessary relations. The relation of cause and effect is sometimes called necessary; but, if so, it is not usually handled mathematically. The relations must, then, be of mental things.

They are not relations between images or imaginations of outside things, for two reasons: First, the relations between imaginations can be no more necessary than the things they image; second, the imaginations of men's minds are different. One may imagine a line as a

chalk-line on a blackboard; another, as the edge of a knife; I myself, as the boundary between crystal faces.

However, in all our minds there is something the same in each. It is the concept or idea. And it is of concepts and ideas that mathematics treats.

Here Mill seems to make a mistake. He says, "The points, lines, circles, and squares which any one has in his mind are simply copies of the points, lines, circles, and squares which he has known in his experience." To his mind, then, the function of thought, when we think of circles, is to reproduce some original sensation more or less vividly. This, however, is what I call imagination; and we have tried to prove that imaginations were not the objects of mathematical treatment. Helmholtz acknowledges this when he says that the axioms of geometry, taken by themselves out of all connection with mechanical propositions, represent no relations of real things.

We will notice certain other facts about concepts and words, in connection with their mathematical relations. The first is the persistence of concepts. By this I mean that an idea once formed, by whatever means, experimental or otherwise, does not depend upon the continual recurrence of the same experience for its continued existence.

That is, having once formed an idea of a baby hippopotamus, by having seen one in Barnum's Great Show, I have that idea, which is called into use on various other occasions—such as hearing of it in the newspapers. It is not at all necessary that I should renew the experience every time Barnum comes around. It is, of course, true that a concept may be disused, but its use may be made common as well by unlike as by like experiences.

However, on closer inspection of the hippopotamus, my conception may be new. This leads us to our other all-important distinction and division. Every name has a denotation and a connotation. Its denotation is usually of things, its connotation is conceptual. Some words, proper names especially, correspond to things, the ideas attached to which vary according to the varying aspect of the thing. Other words, however, correspond to ideas; these words are applied or not to things according as there are experiences coming under the concept to which they are attached.

This distinction between words with fixed denotation and varying connotation and words of fixed connotation and varying denotation is quite important, as we shall see. Let us first, however, return to our hippopotamus. This is a word for me of at least partially fixed denotation; it must include the animal that I saw; it must not include an ordinary pig. The connotation would be almost indefinite. This word has, then, a fixed denotation varying connotation, approximately. On the other hand, take the name, rigid body. This is a name with a denotation varying down to zero, perhaps, but its connotation is changeless.

Thus we see that mathematics may be defined as the science of the relations of concepts. Its vocabulary, too, must be one of fixed connotation. That is why symbols are so useful; their connotation does not vary unconsciously.

Benjamin Peirce defines mathematics as the science that draws necessary conclusions. Mill says, "The problem is—given a function, what function is it of some other function?" It is obvious that necessary conclusions can be drawn only so far as there are relations fixed whence to draw them; the function must be given before we find its relations with other functions.

Now, I wish to insist, as strongly as I can, that *any set of concepts become fit for mathematical handling as soon as their relations are unfolded*, and this is what I have so far proved. If you ask, "Whence these concepts?" my answer is, "From experience." From it comes the "element of intuition" that Stallo says is an element in every geometrical axiom. Space itself is but a product of experience. If a man could only hear or taste, would he have our concept of space? I trow not.

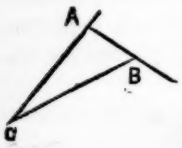
Let us now, after this long digression, return to our transcendentalists. Euclidean geometry and non-Euclidean alike are mathematical. Verbally they come to different conclusions, but neither conclusion affects facts. The difference is here, it seems to me. Transcendental geometry is the offspring of analytic, though some have tried to treat it otherwise. The relations that it handles are at first algebraic relations that may apply to anything. Then applying the geometric nomenclature to algebraic expression, calling expressions of the first degree linear, etc., it interprets these results geometrically. Its definitions, thus, are different from those of Euclid; the ideas connoted by its vocabulary are different; its concepts are not the same. It is not wonderful, then, that it gets a broader field of relations.

We decide, then, that from their respective definitions the Euclidean and the transcendental geometry are true. And this is, perhaps, the most important point to settle, for the transcendentalists have said that, although the geometrical definitions were true, the axioms need not be. We, however, say that the axioms, or what you will, of parallelism, etc., are part of the connotation of the words defined, and are simultaneously given. Of course, some experience is necessary to make us form any concepts.

The question now to be answered is, then, Which are the best definitions? But it must be remembered that, as long as we are dealing with mathematics, we are never dealing with real things. Thus Helmholtz is wrong in saying that by adding any mechanical axioms or principles we can obtain an empirical science out of geometry, if the science thus obtained is purely mathematical.

Mathematical concepts can have two virtues in varying degrees, namely, simplicity and resemblance to, or rather correspondence with,

external reality. First, they must be simple, that is, their relations to one another must be easily handled; second, their relations must correspond more or less closely with the relations of some set of external things. They do not correspond *absolutely*. There are no external things which have the properties of mathematical straight lines except approximately. Take the annexed figure.



One would not hesitate to call A B, B C, C B, straight lines, and to say that the triangle A B C has the sum of its angles equal to 180°. The error he would make (they are drawn with compasses) we always make in kind, though not in degree, in applying mathematics to realities. I wish to make clear that the relation between mathematical truths and external facts is one of resemblance, not identity. What the essence of resemblance is I shall not discuss.

No external facts can do more than change the utility of the two geometries. At present, for simplicity and accuracy of resemblance to external facts, the Euclidean geometry need not fear being swallowed up. If, however, facts should be discovered which could be most simply correlated to transcendental truths, transcendental geometry might become important.

Let us recapitulate. We have tried to show that mathematics deals only with concepts, and that the two geometries are, therefore, also conceptual. Their apparent discrepancy we tried to account for by showing that they used different concepts. We showed that, although concepts might be originated by sensations, they were not, nor were affected by, external facts. The relation between mathematical truths and external facts is one of more or less resemblance, not of identity. Nor can the resemblance be ever proved to be perfect.

The Euclidean geometry has as great facility in accommodating itself to all known facts as the transcendental, and greater simplicity. It is therefore of greater practical utility. The mathematical truth of each is not affected by experience.

Thus transcendental geometry, with its egg-shells turned inside-out without cracking, its knots mysteriously untied, its worlds where the background of everything is a man's own head, is from its conceptual basis, as a creation of man's mind, true. It is a pretty mathematical diversion; it is, as yet, nothing more.

MY SPIDER.

By W. H. T. WINTER.

A SPIDER, sitting placidly on a hat-peg, awakened in me a vague enthusiasm for natural history; so I captured him, and put him in a bottle. He was lean and gaunt, and had an ominous countenance. The small row of eyes on the vertex of his head looked murder and rapine, and the formidable jaws—which he moved slowly, as if he were sucking his teeth—meant death to those who were his inferiors in strength. He seemed to have been lately in distressed circumstances, for the light came through his very carcass, and his legs were almost as weakly as the gossamer he wove. The strongest part of him seemed to be the stiff hairs that covered him. They stood out independently, and covered his body with such profusion that I was led to call him Esau.

The bottle most likely did not impart a generous warmth, and probably the garish light of day was not pleasant to this denizen of the rafters and remote corners, yet he settled himself in his new habitation with a calmness which commanded my admiration. No fear entered his breast; he was not daunted by captivity. He did not wildly seek an outlet, like most of the things we call insects. He seemed to be of the school of the ascetic Brahmans, and apparently regarded fate as invincible.

"Even if I keep you in captivity," I said, "I will provide you with a mansion, and you shall have an amplicity of food." After a little search a wide-necked jar was obtained, and I set to work to catch flies. The jar was glass, and its mouth was covered with muslin; but in case Arachnida cared not for light and ventilation, I provided him with a piece of paper rolled cone-wise, and in this inner chamber he could seek retirement.

On being placed in his new abode, my friend betrayed no curiosity. He merely settled himself on the piece of paper, as it had a more genial feel than the transparent floor. Perhaps he watched me, but I could not tell that from his expression. His face was typical of indifference.

I now began to make havoc among a colony of flies who had apparently spent their lives in obtaining from the window-panes some occult flavor which is not perceptible to our coarser palates. I made three captives, who were passed beneath the muslin door of the jar with a little sleight of hand. The appearance of these flies was my next subject of observation. They each had an individuality which I did not till then know that flies possessed. Their deportment, their figures, their very moral tone, had a distinct stamp; yet there was an harmonious something which united characters so different. The first

had a fluffy appearance, his body looked sodden, and he behaved in a fat and sensual manner. He took the grossest pleasure in warming his ventral surface on the side of the jar toward the sun. He sipped the sweets of life to excess, and had lost that activity a fly ought to possess. Alas! his career rendered him unfit to battle in the struggle for existence. He became the spider's first meal.

The second fly had but one wing. He was lean and ill-nurtured, yet he had withal a chirpy and pleasing manner. He had neither the pompous bearing of opulence nor the boisterous ways of rude health. He was a sweet-tempered and amiable fly, and among the local muscæ undoubtedly occupied the same position that Tiny Tim did in his family. I should have let him go, only that I feared that, if I did so, I should also release the third fly, whom my soul loathed. Now, let me tell you why that fly was objectionable. He was the only fly left on the window-panes, and he walked over them with the arrogance of a landlord. I sought to catch him, but each attempt was more futile than the last. He dodged, he flew away from the window, he calmly floated about the room, and I followed him, flapping with my pocket-handkerchief till I visibly perspired. He was as cunning as the fox of Ballybogue, who, you remember, used to take in the newspaper to see where the meets were to be. My temper overcame me, and I swore I would have that fly.

After a hunt, which brought out all my worst characteristics, I caught him, and deposited him in my vivarium, rejoicing to myself that his death-agonies would be some compensation for my pains. As soon as he got into the jar, Mr. Fly discovered that his poor little brother in adversity had a raw place where his wing had been torn off, and he would follow him from place to place to put his sucker on to the sore. It was not the kindliness of the dogs of Lazarus which led him to lick the wound. He saw that Tim did not like it, and, as he was a nasty, bullying cad, he persisted in his obnoxious performances. I left him disgusted. He was a beast!

In the course of an hour or so I returned. The sensual fly was in the arms of the spider. The hunter, with his quarry in his clutch, was on the piece of paper, and I could see him well. Four black bead-like eyes, situated on the very summit of his head, gleamed at me with ferocity. His mandibles were stretched to their utmost. The hooked extremity of one was driven into the fly's eye, the other was fixed somewhere about its throat. Between these a pair of jaws were working with a synchronous and scissors-like movement, and his upper and lower lip (for such they were, I afterward learned) worked, as it were, between whiles. As the jaws approached each other, the lips parted. His palps, or leg-like antennæ, waved slowly as the tail of an angry cat; and his very spinnerets, six in number, stood out turgid with excitement. The fly was still, except for a quivering motion of one of its legs. It was the tremor of death.

For ten minutes, at least, the spider did not move a limb. The palpi forgot to wave, and he abandoned himself to the full and gross enjoyment of his meal. I forgot the fly's agonies. This poor starved creature, safe from the persecution of the house-maid, was reveling in the juices of a luscious fly. The gloom of his life was dissipated by a bright spot. Starvation even had a charm when followed by such a meal.

At last he fixed the fly against the paper with one foot, and loosened his grip, and, after giving a sigh of satisfaction, proceeded to decapitate his prey. He then held the carcass in such a manner that I thought he was going to blow into it, but he did not. The pangs of hunger were assuaged, and, with an Epicurean manner worthy of Brillat-Savarin, he sought for some dainty morsel in the chest.

Half an hour after, he still lovingly held his prize, although he ate no longer. The child-rhyme was floating in his memory:

"Oh, what fun!
Nice plum bun!
How I wish
It never was done!"

I went to bed, and on the morrow another corpse, that of Tim, lay on the floor of the bottle. His expression was placid as in life, and there was that beast of a fly, whom I described before, sucking at the old wound.

Days went on, and Esau's digestion seemed a laborious process. I watched with eagerness to see whether he would lay his hands on his companion by force or fraud. The spider lay immovable, the fly was idly busy in security.

Now, the utter disregard of decency paraded by that fly would have sent a cold shiver down the spine of any proper-minded person. He hustled the corpses of his brethren who were dead. He was constantly trying to extract from their bodies what juices the spider had left. He turned them on their stomachs. He turned them on their backs. He had no regard whatever for the deceased.

I sat in my arm-chair and pondered over the levity of that wretch till the dinner-bell rang, and I went sorrowfully to my evening meal. "How much superior am I to that fly! If a steak from one of my fellow-creatures were laid before me, I should reject it with abhorrence," thought I, "even if it were garnished with the savory onion or the mushroom—ay, even if it were relished with oyster-sauce and the tenderest asparagus. It is only the worst grades of life which can feed upon their kind."

We had chickens for dinner. The liver wing was excellent, and the en-dedâns of the back afforded pleasant picking. I begged the maid to preserve the bones for a broken-legged dog whom I had adopted.

My plate was brought on to the lawn, and on it were the remains of the fowls; and the dog was carried out with all care to enjoy his meal on the grass. Poor old thing! His tail wagged with a steady flap, his eyes glistened softly, his neck was outstretched, and his nose was agitated with a delicate twitching till he was placed beside his repast. Then he fell-to, and with admirable judgment selected the most meaty morsels to commence with.

It was lucky that he had finished two pinions, for "the Philistines were upon him." A pea-hen close by heard the crunching. She listened. Curiosity seized her, and she looked at the eater, first with one eye, then with the other. (That was mere coquetry, as it gave her an opportunity of showing off the graceful movements of her neck.) She approached a few steps with stagy dignity; she saw there was food, and the bird of Juno, forgetting her state, ran with an ungainly and slop-slap step toward the plate.

The bird was large and powerful, and the dog was small and an invalid. He therefore secured the best advantages that the circumstances afforded, and sneaked off on three legs with a drumstick.

"Gristle?" quoth the pea-hen; "excellent! Tendon? better still."—Gaup, gaup.—"A small bone? 'twill do me no harm." Down it went.—"A little picking?"—peck, peck.

"Thou cannibal!" thought I, "those are the remains of thy companions of the farm-yard. That fly is not so unnatural, after all. I will let it go."

My resolution was short-lived. Two hours ago there were but a spider and a fly and a piece of paper in the glass jar. Now my friend the spider was evidently getting hungry, and he was exerting himself. Two strong cords were drawn from the paper to the bottom of the jar, and Esau meant business. His spinnerets were turgid, his aspect was determined, and steadily and slowly he commenced to make a web. Now and then the fly took a walk and broke through a strand or two. They stuck to his legs, and annoyed him. With a little difficulty the films were got rid of, but consternation began to seize the fly's mind, and he resolved to move from the scene of operations. He took up his quarters on the muslin which covered the neck of the jar.

Next morning the fly's head hung like a Bulgarian atrocity in the web, his body lay at the mouth of the spider's den. During the night Esau had made a cavern of cobweb.

It is the duty of the historian to adhere to the truth, even if it casts a slur on his favorite theories, and blasts his reputation as an observer.

Esau was not a male: he was a lady.

One day, while feeding the beast, I noticed that the den in the corner had been extended into a passage with two openings, and in the passage wall was a spot thicker and more opaque than the rest of

the building. This I surmised was a deposit of eggs, and I afterward found that I was right.

Still, I had named the animal; and, on the principle of the parson who insisted on christening the little girl John, I adhered to the original appellation. Hitherto the spider had discovered none of the attributes proverbial to her sex, and I did not feel justified in naming her Lucy or Maria.

There were warm days that year, when the air smelled of clover, and flies came out plentifully, and Esau was fed on all available insects that had wings. The house-fly was her staple food, although she regarded small moths as delicacies, and thought midges and small gnats were toothsome articles of diet; but her soul loathed blue-bottles. They were to her what caviare and absinthe are to the uneducated. If a blue-bottle was put into her net she bound it down with many strands of cobweb, and killed it, and, before the animal had ceased to quiver, cast it from her web with evident repugnance. Beetles she did not care for, as they broke her web; but money-spinners she tolerated. Daddy-long-legs fell an easy prey to her, although she did not relish them. That I know, because she never took their carcasses to her cave.

By way of a treat I once offered her a small earth-worm. It wriggled and writhed, lengthened itself and shortened itself, assumed the shape of a corkscrew, and tied itself up into knots. Esau sought refuge in her house, and stuck her head out to watch these strange manœuvres. At first, she was as still as possible; then there was an oscillatory movement of the palpi. She generally did that when she was getting up her pluck. Then she made a rapid rush to within an inch of the worm, and reconnoitred again. She was not satisfied, and retired a second time to think the matter out. The worm, in the mean time, either got tired of struggling, or else philosophically arrived at the conclusion that he could make himself as comfortable in a cobweb as in any other place. The period of rest was fatal. Esau darted on her prey and stuck her mandibles into him. Vainly did the worm try to charm the enemy by tickling her with the end of his tail. Esau held on like a vice. The worm tried to encircle her body with furtive gyrations. Esau had no inclination to play at Laocoon, and eluded the strategy of his prey. That worm gave in.

I began to get tired of my pet. She was getting fat; and the fatter she grew the more ferocious she became. I sought another spider, and found one smaller than the one I possessed. To my mind it was of the same species, but from its size I imagined it was a male. "I will be the historian of the loves of spiders," I said. "Their domestic happiness shall be a moral to mankind. Two spiders together will give me an opportunity of making fresh observations."

I was not disappointed, but my researches gave a result that I had not anticipated.

When I put my finger near the new spider he gathered his legs together, and assumed an abject attitude; perhaps it was a simulation of death. Anyway, the position gave me the idea of meanness and knavery; so I called him Uriah Heep, because he was "so 'umble."

"Esau," I said, with befitting solemnity, "wilt thou take Uriah to be thy wedded husband?" I dropped him into the jar. The lady was sitting in her web; but she bolted into her chamber the moment she felt the impulse of the fresh arrival.

"Ah," thought I, "she is parading her coyness."

Uriah did not seem at his ease, and, leaving the cobweb, he took up a position between the paper and the wall of the jar. Esau protruded what ought to have been her nose—had she belonged to a higher species—from the doorway of her sanctum. There was evident uneasiness on both sides.

Now, I do not believe that these two creatures slept for two days and two nights. They regarded each other with profound suspicion. I put flies into the jar. They would not be allured by food. If one moved the twentieth part of an inch, the other altered its attitude to a similar degree. If Esau wished to get out of her apartment, Uriah occupied a different strategical position. It was a period of brain-tension, watchfulness, and terror.

On the third morning I found Uriah had fallen a victim. His thorax was separated from his abdomen, his legs were disarticulated and scattered, and Esau sat on her perch, placid and contented, the mistress of the situation.

Spiders of both sexes and of every shade of opinion successively shared the captivity of Esau, and they all shared the fate of Uriah. The blood of Mr. Heep had whetted the appetite of the Amazon, and she increased in valor and ferocity. She gauged the strength of her opponent with infallible precision. Now she would use all the arts of strategy; now she would trust to the prestige of victorious arms. Her jar became a very charnel-house of the remains of her kind. A battle occasionally took place, but superior strength and agility made Esau victress. As a rule, however, the new intruder said Kismet the moment it was seized, and resigned itself to fate.

I have yet to relate the most interesting part of my narrative. Pardon me whispering, reader; but Esau has yet to become a mother. The queen of the pickle-jar, who directed the destinies of her subjects —and I must say she directed them in pretty much the same direction —was herself to become the slave of a numerous progeny. It has been an enigma to me who the sire of that progeny could have been.

"No scandal against Queen Elizabeth, I hope?"

Reader, I assure you, my duties are those of a grave historian. I am no carrier of tattle.

It has been an enigma to me (allow me to resume the subject) who the sire of that progeny could have been. Perhaps it was some

spider of ancient lineage, who did valiant battle in his ancestral cobwebs against predatory wasps. Perhaps he had won Esau's young affections, and become master of her charms. Perhaps it was some errant knight, who had vowed the extermination of the whole race of parasites which infest the spider's body. Perhaps it was some wealthy spider, who owned vast demesnes of netting, which extended over many a rafter, and offered hunting-ground for many a retainer. Perhaps her spouse was remarkable for his personal beauty, and had carried off her heart by his comeliness. I know that no spider base-born could have been the father of her offspring. Her behavior to Uriah Heep forbids so gross a surmisal.

Then, how was it that she was alone on the hat-peg? The aristocrat might have spurned her from his home from the prospect of a more advantageous alliance. The enthusiast might have doubted her intensity, and so deserted her. Dives might have been jealous, and have procured an act of separation; Adonis probably spirited away by some light of love.

Her history is open to conjecture alone. The fact remains, that she laid eggs, and they were hatched.

If my memory be not deceived, the small spiders appeared a fortnight or three weeks after I first noticed the eggs. When first born, they were small, yellowy-white, and indefinite, like cheese-mites—just what one would imagine spider-babydom to be. They moved at a pace almost imperceptible from its slowness, and their gait was weak and vacillating. As well as I could make out with the naked eye, they were constantly tumbling on their sides for the first few days. They seemed to meet with obstacles which are not apparent to our gross vision.

I thought the sun would be grateful to them, and their jar was placed on the window-sill. Either the warmth suited them, or baby spiders gain strength rapidly; for, before three days were over, Esau's offspring became marvels of agility. When they were at one end of the piece of paper, urgent business called them to the opposite extremity of the cone, and they ran as fast as their small legs could carry them. If they were on the floor of their home, urgent reasons induced them to promenade the ceiling. Occasionally one little chap would take a long journey around the floor of the jar, while another would start off on a commission of inquiry, and investigate the construction of the cobweb with the minutest care. A third would mount its mother's back, and crawl over her out of sheer curiosity. No pair of them ever seemed to do the same thing at the same time. I never saw them feed; but during the next week or two they increased in size and strength. Esau contemplated them with pleasure; her character was softened. Dozens of flies were put into the jar, but few were killed. Some became entangled and died in the toils, but the majority occupied the top of the jar, and especially affected the mus-

lin doorway, which was moistened for their delectation with sugar and water.

The time for my summer holidays arrived, and I started for the south, leaving Esau to look after the house.

The friendship I had struck up with spiders certainly increased the pleasure of my trip. I found my friends in numbers everywhere I went. They were on the shady side of dock-leaves. They floated in the air and settled on my hat, and were carried off by the next breath of breeze. I found their webs in profusion between the branches of a monkey-tree in the garden; and in the corn-fields myriads of these small creatures trapped flies that were almost microscopic. On the sandy slopes of the sea-shore, cobwebs were among the gorse-bushes. The diadem spiders in the rose-trees vied with each other in the regularity of their nets, and every barn was rich in arachnean architecture. I had heard of water-spiders, and I hunted for them assiduously in every pool and stream in the neighborhood, but with no success. I found no water-spiders, but I became the possessor of many inhabitants of the ponds.

Three weeks passed too quickly, and I had to return to my work and to Esau. Alas! what a lamentable sight met my eyes! Esau was dead, and her children were certainly fatter than when I left. I could arrive at but one conclusion. The dauntless adventuress who had gloried in murder and fratricide had become the victim of misplaced love. Those little wretches whom she had brought into the world, and cared for and nurtured, had turned upon her and slain her and sucked her life-blood. Ah, poor mother, thy antecedents might not have been good! Possibly thou mightest have dined off thy husband or thy paramour—certainly thou hast waged unnatural though valiant war against thy kind; still, that was no reason why thou shouldst have been sacrificed by thy offspring in the bloom of thy maturity.—*Gentleman's Magazine.*

SUDDEN WHITENING OF THE HAIR.

WITH so many professors of the art of rejuvenation proclaiming their readiness to turn old faces into new ones, smooth out wrinkles, obliterate crow's-feet, and restore the hair to its original abundance and color, the putting of young heads upon old shoulders should be easy enough; but the proverbial impossibility of putting old heads upon young shoulders still seems to hold, although the feat has sometimes been accomplished by Nature herself. Sorrow, not Time, frosted the bright tresses of Mary Stuart and Marie-Antoinette; and theirs were not the only queenly heads that have been prematurely

whitened by care and anxiety. While Hanover was waging an unequal contest with Prussia, a lady in attendance upon the consort of the brave, blind king, wrote thus of her royal mistress: "In the last two months her hair has grown quite gray, I may say white. Four months since one could scarcely discern a gray hair; now I can hardly see a dark one."

A similar change has often taken place in the course of a single night. One of the witnesses in the Tichborne case deposed that, the night after hearing of his father's death, he dreamed he saw him killed before his eyes, and found, on awaking, that his hair had turned quite white. An old man with snow-white hair said to Dr. Moreau: "My hair was as white as you see it now, long before I had grown old. Grief and despair at the loss of a tenderly loved wife whitened my locks in a single night when I was not thirty years of age. Judge, then, of the force of my sufferings." His white hairs brought no such recompense with them as happened in the instance of the gay gallant who had the hardihood to hold a love-tryst in the palace grounds of the King of Spain. Betrayed by the barking of an unsympathetic hound, the telling of the old, old story was interrupted by the appearance of the king's guard. The scared damsel was allowed to depart unchallenged; but her lover was held captive, to answer his offense. Love-making under the shadow of the royal palace was a capital crime; and so overwhelmed with horror at the idea of losing his head for following the promptings of his heart was the rash wooer, that, before the sun rose, his hair had turned quite gray. This being told King Ferdinand, he pardoned the offender, thinking he was sufficiently punished.

When the Emperor Leopold was about to make his grand entry into Vienna, the old sexton of St. Joseph's Cathedral was much troubled in his mind. Upon such occasions it had been his custom to take his stand on the pinnacle of the tower and wave a flag as the imperial pageant passed by; but he felt that age had so weakened his nerve that he dared not again attempt the perilous performance. After thinking the matter over, he came to the conclusion that he must find a substitute; and knowing his pretty daughter had plenty of stalwart suitors, the old fellow publicly announced that the man who could take his place successfully should be his son-in-law. To his intense disgust, the offer was at once accepted by Gabriel Petersheim, his special aversion, and the special favorite of the girl, who saw not with her father's eyes. On the appointed day Vienna opened its gates to the new-made emperor; but it was evening, or near upon evening, when the young flag-bearer welcomed the procession from St. Joseph's Tower. His task performed, Gabriel would have descended from the airy height, but found his way barred. Two wretches had done the treacherous sexton's bidding, and closed the trap-door of the upper stairway, leaving the brave youth to choose between precipi-

tating himself on the pavement below, or clinging the cold night through to the slender spire, with but ten inches of foothold. He chose possible life to certain death; but, when rescue came with the morning, his eyes were sunken and dim, his cheeks yellow and wrinkled, his curly locks as white as snow. Gabriel Petersheim had won his bride at a fearful cost.

Believing a fortune might be easily won in the oil-country, a young Bostonian went there to enrich himself. One stormy night a glare in the sky told him that an oil-tank was on fire a few miles off; and knowing that, after a time, the oil would boil up and flow over the side of the tank, he made for a hill to witness the spectacle. "She's coming!" a man shouted. There was a rumbling sound, and then the burning oil shot up from the tank, boiled over its sides, and floated down the creek, destroying everything in its way, and setting fire to a second tank. Curiosity getting the better of discretion, he ran to the ground in the rear of the tanks, to get a better view, and, in trying to avoid a pool of burning oil, fell into a mud-hole, and stuck fast therein. Struggling till he could struggle no longer, he lay back exhausted, watching the billows of smoke surging upward and floating away into space. Suddenly his ears were startled by the sound of cannon-firing; a column of flame and smoke shot up from one of the tanks, and he was stricken almost senseless with the knowledge that the "pipe-line men" were cannonading the first tank, to draw off the oil, and so prevent another overflow. He tried to shout, but the words would not come. A little stream of burning oil ran slowly but surely toward him. He watched it creeping on until it was almost upon him; then in a moment all was dark. When he came back to consciousness he found himself in his own room, surrounded by "the boys," who had seen him just in time to save him. It was a weary while before he was himself again, and then he was inclined to doubt if he was himself, for his once dark hair was perfectly white.

Instances have not been wanting of the hair being deprived of its color in a few minutes. The home-coming of the King of Naples after the Congress of Laybach was celebrated with much public rejoicing. To do the occasion honor, the manager of the San Carlo Theatre produced a grand mythological pageant, in which an afterward well-known opera-singer made his *début* in the character of Jupiter. The stage-thunder rolled, the stage-lightning flashed, as the Olympian monarch descended on his cloud-supported throne. Suddenly screams of horror rang through the house; the queen fainted, and all was uproar and consternation, until the voice of the king was heard above the din, crying, "If any one shouts or screams again, I'll have that person shot!" Something had gone wrong with the machinery before the clouds had descended ten feet, and Jupiter had fallen through. Fortunately, a strong iron wire or rope caught his cloak, and, uncoiling with his weight, let him down by degrees. But

a workman falling with him was impaled upon a strong iron spike supporting the scenery. In ten minutes or so they reached the ground, the workman dead, the singer dazed, but able to thank Heaven on his knees for his escape; and then the awe-stricken people saw that the black-haired deity had become transformed into a white-haired mortal, whose youthful features formed a strange contrast to their venerable-looking crown.

Staff-surgeon Parry, while serving in India during the Mutiny, saw a strange sight. Among the prisoners taken in a skirmish at Chamda was a sepoy of the Bengal army. He was brought before the authorities, and put to the question. Fully alive to his position, the Bengalee stood almost stupefied with fear, trembling greatly, with horror and despair plainly depicted on his countenance. While the examination was proceeding, the by-standers were startled by the sergeant in charge of the prisoner exclaiming, "He is turning gray!" All eyes were turned on the unfortunate man, watching with wondering interest the change coming upon his splendid, glossy, jet-black locks. In half an hour they were of a uniform grayish hue.

Some years ago a young lady who was anxiously awaiting the coming of her husband-elect, received a letter conveying the sad tidings of his shipwreck and death. She instantly fell to the ground insensible, and so remained for five hours. On the following morning, her sister saw that her hair, which had been previously of a rich brown color, had become as white as a cambric handkerchief, her eyebrows and eyelashes retaining their natural color. After a while the whitened hair fell off, and was succeeded by a new growth of gray. This case coming under the observation of Dr. Erasmus Wilson, shattered his unbelief in the possibility of the sudden conversion of the hair from a dark color to snow-white. No man knows more about the hair than Dr. Wilson; but he is at a loss to explain the phenomenon quite to his own satisfaction. "If," says he, "it be established that the hair is susceptible of permeation by fluids derived from the blood—a transmission of fluids from the blood-vessels of the skin into the substance of the hair really occurs, the quantity and nature being modified by the peculiarity of constitution or state of health of the individual—it follows that such fluids, being altered in their chemical qualities, may possess the power of impressing new conditions on the structure into which they enter. Thus, if they contain an excess of salts of lime, they may deposit salts of lime in the tissue of the hair, and so produce a change in its appearance from dark to gray." Then he tells us: 'The phenomenon may be the result of electrical action; it may be the consequence of a chemical alteration wrought in the very blood itself, or it may be a conversion for which the tissue of the hair is chiefly responsible." So many "may-bes" from such an authority prove that the mystery of the sudden whitening of the hair is yet unsolved. It is likely to remain unsolved, since the doctor—more modest than

many of his brethren—owns that "the mysteries of vital chemistry are unknown to man."

The whitening of the hair wrought by mental disturbance is sometimes only of a partial nature. Vexation of spirit gave Henry of Navarre a party-colored mustache. An old writer tells of an Irish captain going to deliver himself up to Lord Broghill, the commander of the English forces, who, being met on his way by a party of English soldiers, was made prisoner, and was so apprehensive of being put to death before Lord Broghill could interfere in his behalf, that the anxiety of his mind turned some of his locks quite white, while the others remained of their original reddish hue. Perhaps the curious change was less annoying to its victim than that which befell an American girl, whose first intimation of her lover's falsity was the reading an account of his marriage in a newspaper. After a night's brooding over the traitor's perfidy, her looking-glass showed her that one side of her head was still adorned with tresses of golden brown; but the other, alas! was decked with locks more befitting a grandam than a maiden still in her teens; though even this was not so bad as was the case of a French girl, who, frightened by the floor of her room giving way beneath her, shed her hair so quickly that in three days' time she was—to use the expressive comparison of a chronicler of the event—"as bald as a bell-handle."—*Chambers's Journal.*

HOW PLANTS RESIST DECAY.

By W. O. FOCKE.

THE destruction and decomposition of organic substances, both animal and vegetable, are promoted by the lower fungoids, particularly by yeast-plants and molds, which we may for brevity call rots. During life, that is, as long as a lively circulation is kept up, plants are protected against the attack of these ever-present organisms, but during the periods of rest, when the life-activity of the plant is reduced to a minimum, defense by the vegetative process is suspended. The older parts of plants, also, in which the normal circulation has become very limited, are poorly fitted to resist decay. It is, therefore, a question how it happens that perennial plants are so rarely attacked by the lower fungoids during their periods of rest.

The best protection is afforded by a firm epidermis, especially if it is fortified against the persistence of moisture upon it by a coating of wax. The importance of epidermal protection is exemplified in the North American opuntias, which bear the Central European winters quite well. If any part of the stalk has suffered an injury which has

destroyed the outer skin, even if only for a very small space, decay begins at the wound, and spreads till it destroys the branch, unless warmer weather quickens growth in the weakened plant, when the process comes to a stop.

The most common protective armor of the higher and woody plants is the cork-bark. The corky substance is of itself extraordinarily tough, and even when dead is only very slowly destroyed by molds. Tree-barks also appear generally to contain chemical substances that operate as poisons upon the lower organisms. The most commonly diffused of such substances are tannin and other coloring-matters allied to it. Many barks also contain strong bitter matters and alkaloids, like salicin, pinipicrin, quercitrin, æsculin, chinin, aricin, strychnin, berberin, etc. The most persistent waxes also reside in the bark, and ethereal oils in individual cases, as in the laurels. The general diffusion of these substances in the bark is the more remarkable because they are rarely found in the wood or the annual leaves.

The subterranean parts of plants need the same protection as the stem. Swamp-plants in particular, which grow in a soil always undergoing decomposition, would fall a prey to decay very quickly without some especial defense. All plants whose organization does not insure them against the action of swamp-soil, perish alike, even under exposure in the winter, at any other time than during the growing season. The under-ground parts of plants growing in such soils are protected in part by the hard epidermis, partly by coloring-matter, as in the alder, comarum, and sanguisorba; or by bitter constituents, as in menyanthes; or by ethereal and aromatic substances, as in valerian and acorus; or by acrid matter, as in frangula and the *Ranunculaceæ*. Antiseptic substances, such as tannin, saponin, and phloridzin, are also found in the underground organs of plants that do not grow in swamps, and the strong essences of the rhizoma of ferns and of the punica-root belong to the same class.

Evergreen leaves, besides requiring means of defense against the lower organisms, need protection against the higher animals, which would consume them during the winter if they were quite accessible and enjoyable. Ulex and Ruscus, therefore, have thorny limbs, smilax and the evergreen brambles and roses have spines on their leaf-nerves, juniper and the holly-leaved plants have thorny leaves. The foliage of yew, arbor-vitæ, ledum, rhododendron, oleander, and laurocerasus is poisonous; and the palatableness of the leaves of pine and spruce, of laurel, ivy, and box, is at least very limited. Only the common underwood, consisting mostly of plants of the heath family, which are to a great extent covered during winter by leaves and snow, contain food for animals in their leaves and twigs. These leaves are likewise defended against rots by the poison in the poisonous kinds, by the hard, bright epidermis in the hollies, and presumably by chemical qualities; the heaths contain a coloring-matter.

Among the fruits, the juicy ones are designed to be eaten by animals, which are to serve as the medium for scattering their seeds. It is, therefore, of advantage to the plant to have its fruit valuable to some animal. The fall season affords an excessive abundance of fruits, but the best and most palatable ones are exposed to speedy destruction. It is, therefore, an advantage to animals, especially to birds, and to the plants likewise, if a few fruits have keeping qualities, that is, are able to resist decay, even if it be partly at the expense of their pleasant taste. This is the case, for example, with the berries of juniper, yew, holly, viburnum, and cowberry, whose persistence appears to depend partly on a hard epidermis, partly on chemical qualities; on an ethereal oil in the juniper-berry, apparently on benzoic acid in the cowberry. Ivy-berries do not ripen till winter.

Seeds are protected by their hard casings or by chemical substances. The poison contained in seeds may in part answer the purpose of preventing their being consumed by animals; but many seeds, as for instance the aromatic seeds of the umbelliferæ and other plants, contain not poisonous but antiseptic substances. The fatty oil, which is so abundantly present in seeds, is perhaps as valuable as a means of protection as for food. The oil as well as the shell of the seed prevents the entrance of water at low temperatures; and, unless water is present, the dry seed can not be attacked by the germs of decay.

If we survey the vegetable products that afford active chemical agents, we shall find that they are predominantly the bark, roots, and seeds. The coloring-matters, the bitter products, the alkaloids, and the poisonous substances are for the most part obtained from these organs. The leaves which afford such powerful matters are generally evergreen. Indeed, there are poisonous plants (among the nightshades, *Araceæ*, and *Personatæ*) and certain poisonous bushes (dogbanes and cashews) which are protected by this quality against the teeth of animals. The ethereal oils serve further in many plants, as among the labiates, the rues, the myrtles, and some geraniums, for protection against the heat of the sun, the reduction of temperature produced by the evaporation of the oils compensating in some degree for the insufficiency of the water which the plants are able to draw from the soil. Aside from these particular cases, however, chemically differentiated substances do not occur abundantly in the leaves or the wood of summer-green plants. Yet a protection of the wood against the germs of decay is evidently not at all superfluous. Wounds are often made upon trees by mechanical injuries, dying limbs, etc., from which decay may penetrate to the interior of the tree. Hence, we quite often find the wood rotten in the interior of a living tree. It is, therefore, also an advantage if the wood is defended against the attacks of rot by its finer texture, by gums, or by antiseptic substances like camphor, quassine, berberin, or columbin.

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The great diversity of the chemical combinations that plants, instead of applying for their proper growth, store up in their tissues as a means of protection against the heat of the sun, the lower fungi, or animals, is really astonishing. Even in the liverworts we meet different substances neither the chemical nature nor the biological importance of which is clearly enough known. Among the ferns, only the under-ground stems are endowed with substances of strong qualities. Only single groups among the monocotyledonous plants, and of these the leaves (*Araceæ*) or the flowers (*Melanthaceæ*, lilies) of which show a higher organization, possess acrid poisons or alkaloids or aromatic substances. Among the conifers and dicotyledonous plants the strong substances are very widely diffused in the more enduring kinds.

We have not considered the coloring-matters and odors of the flowers and fruits in this sketch, for they do not serve for protection, but to attract animals.

It is worthy of remark that plants which produce particular substances may be naturalized in regions in which those substances are not required by them. The labiates and rues, which originally belonged to hot climates, still produce ethereal oils in Northern and Central Europe, although they no longer need protection against the hot sun. Closer reflection on the facts we have set forth will show that the real relation must be properly presented as a whole.

Numerous observations, nevertheless, are still necessary in individual cases to make the true significance of each particular phenomenon clear.—*Kosmos.*

THE TOPMOST COUNTRY OF THE EARTH.

By Lieutenant G. KREITLER.

THE name Thibet, as we call that highland, the natural isolation of which gives it a unique position in the world, is not known among the people who inhabit it. The Thibetans call their country Bod, or Bod-yirl; the inhabitants of the northern slopes near the great desert call it Tungut; the Chinese, Si-fan. The highland proper rises in the form of a huge elongated segment of a circle from the adjacent lowlands, and is formed by Nature herself, through the sharply defined rocky precipices that inclose it on every side, into a separate part of the world. The country is bordered on the south by the heaven-aspiring crests of the Himalayan system, consisting of three nearly parallel ranges, the southernmost of which forms the real roof of the Thibetan highland. Impenetrable tropical woods rising from the fever-breeding forest and swamp lands are met at a considerable height by the pine-growths, the whole forming a wonderful panorama; above these rise

the rocky walls bearing in their clefts the eternal ice which glitters and sparkles in the clear sunlight like a gigantic diamond. Similar in structure, but made more imposing by the fact that the steep precipices are planted directly on the untilled plain of the Tarim basin, without any notable intermediate slopes, rises the extreme chain of the Kuen-lun system as the northern boundary of the Thibetan highland. The western boundary is formed by the chain of the Karakorum, with its Triassic and Carboniferous formations, and the furrowed Pamir plain; and the eastern boundary by the curved declivities of the Himalaya system itself, descending with a somewhat more gentle slope toward China. Penetrated by numerous streams which, as a whole, maintain a north and south course, the intervening mountain-regions present formidable impediments to communication. The traveler is overlooked from all directions by icy mountain-peaks that rise to an average height of at least twenty thousand feet. The high table-land itself presents a sad aspect. The enormous height and the climatal conditions dependent upon it restrict vegetation within a narrow limit. No trees are found there, or cultivated fields, no flowers or fruits; and the green spots on which the stunted lavender maintains a precarious existence may be counted among the broad basins filled with gravel and pebbles. The winds bring no moisture. The sparse snow-falls of the year are not enough to impart productivity to the earth, and the plateau is nearly destitute of animal and plant life.

The Thibetan settlements are almost entirely situated in the valleys of the larger rivers, which the relatively lower situation, the higher degree of moisture in the atmosphere, and the possibility of irrigation enable the inhabitants to bring to a measure of tillability. A certain degree of fertility of the soil of the capital can not be denied. Two principal rivers have their sources at a nodal point in the Himalayas, whence they cross the more southern country and India from left to right. They are the Indus in the west and the Sampo in the east. The course of the Indus is well known and marked, but all that has been ascertained of the Sampo is that it maintains a nearly easterly course to southeast of Lassa, after which it is still in doubt whether it becomes the Brahmapootra or the Irrawaddy.

The climate is very severe. The temperature in winter often falls to from 13° to 22° below zero; all the rivers and lakes are covered with ice as early as November, and even in April the sun has not acquired vivifying force enough to melt their crystal surfaces.

No European is allowed to pass over the southern boundary of this country. The East Indian Government has made several attempts to gather information about it, but has been baffled. Colonel Montgomery, a few years ago, conceived the idea of instructing young Indian Buddhists in geography, and sending them to Thibet in the guise of natives. Carrying only indispensable instruments with them, they have been exploring the plateau since 1865, and have till recently

returned regularly to India with valuable information. The suspicion of the Thibetans was, however, at last aroused, and a pundit sent in 1879 was not allowed to reach Lassa, but, some of his words having been overheard and his mission divined, he was compelled to flee, leaving most of his baggage behind him. An imperfect map of the country was made in the beginning of the eighteenth century, by order of the Emperor of China, with the aid of the Roman Catholic missionaries, but its data rest upon report rather than upon the results of actual observation. It has been, however, the foundation on which all our maps of the region have had to rest.

The Thibetan legend of the origin of the people is that, in the beginning, only one man and his three sons lived on the table-land. They had no houses or tents, but led a migratory life, without being troubled with the cares of existence, for the land was not then desert, or poor, or cold. Trees were growing which afforded choice fruits, rice flourished without man having to labor to raise it, and the tea-plant thrived in the fields that Buddha afterward changed into stony places. Thibet was then all the more a fortunate, rich land, because these four men, then the only living creatures in the world, knew nothing of war and contention, but lived in unity and peace. At last the father suddenly died. Each of his sons wanted his body, to dispose of it in his own way. This was the first dispute. The corpse lay for some days on a large rock, and the sons avoided one another. At last the eldest son made a proposition: "Why should we be alienated because a misfortune has happened to us all in common? Let us be agreed, and divide the body." They all accepted the proposition. The corpse was divided into three parts, and each son took a part. The eldest son got the head. He went away toward the east, and became the father of the Chinese, who excel in craft and have great skill in trade. The second son was satisfied with his dead father's limbs. He also left his home and settled where the great Desert of Gobi gives his posterity, the Mongols, plenty of room; their characteristic is restlessness. The youngest son received the breast and bowels. He remained in Thibet, and from him are descended the Thibetan people, who are distinguished in ordinary intercourse by good nature, openness, and cordiality, in war by courage and enthusiasm.

The knowledge that Ptolemy had of the country consisted of obscure sketches which were closely connected with stories of the Chinese capital. Herodotus tells something of the wealth of the land in gold. He says that the gold was found by ants and collected by them into large heaps which were guarded by griffins; and he also tells that a number of Hindoos once got into the country at night when the guardians were asleep, gathered up as much gold as they could carry away on their shoulders, and went back to their homes rich.

The expedition of Count Szechenyi, to which I was attached as a

geographer, was permitted, a little more than a year ago (in 1880), to add a little to our geographical knowledge of the eastern part of the Thibetan highland, particularly of the table of Chung-yen, where no European had ever before penetrated. The priests used every means in their power to prevent our carrying out our project of going to Lassa; and, when they at last came out against us with a thousand soldiers, we were compelled to leave the main road and force our way to the south.

The Thibetans belong to the great Mongolian race, but they are distinguished in many respects, and to their advantage, from their congeners, the Mongols proper and the Chinese. The external characteristics which they have more or less in common with them are the small black eyes, the prominent cheek-bones, the flattened nose, large mouth, and thin lips. They are, like all mountaineers, stout and strong. When I saw Thibetans for the first time at Ta-tsien-lu, I was prepossessed with them. They had come down out of the high mountains and wild clefts expressly to see us Europeans. The contrast between them and the Chinese was made clear not only by their imposing appearance, but also by their earnest quietude and the grave demeanor they maintained in the midst of the crowd of shrieking and boisterous Chinese townsmen. These robust, muscular figures, with weather-browned, wrinkled, thin, earnest faces, were the people called "wild" by the Chinese; and their black, deep-set eyes, framed in a tangled forest of straggling hair, glowed with the fierce fire of religious fanaticism.

The men are always armed, if not with a Chinese matchlock, with the sword of their country, a weapon often of marvelous workmanship, having the hilt adorned with turquoises and the sheath richly chased. Every one wears on his breast, as an amulet against evil spirits, a casket of gold, silver, or copper, containing various forms of incantation. The women and girls, with their two braids of raven hair, their brightly colored, chubby cheeks, their ample drapery, and their precious ornaments of metal and jewels, drive their puny Chinese rivals quite out of the field of comparison. Variety rules in the Thibetan dress, particularly in the arrangement of the women's hair. Sometimes it is worn in two braids, sometimes re-enforced with great structures of yak-hair; always, if the wearer is able, adorned with jewels, silver ornaments, or strings of coins. The women's faces are never clean, but the custom prevails of soiling them purposely.

Their dwellings are situated, either scattered or in little hamlets, wherever tillable soil can be found. Their houses rather resemble defensive towers than residences: they are made of drift-stones, of one story or more, and are expected to accommodate the domestic animals as well as the family; and, if the house is of one story only, the arrangement is apt to be rather promiscuous. The separation is more effective if the house has an additional story; but in the houses of

the better class the only means provided for the family to reach the upper stories are split trunks of trees, with notches for steps cut in the round side. The rooms are dark and gloomy, well ventilated through the half-stopped chinks in the walls, with a fire in the middle of the floor, and light bunks or the floor itself for beds, but innocent of any other furniture except a low table and two or three skin mats; chairs and benches are known only by hearsay. The only roof is a flat platform over the rooms, on which the crops are spread in dry weather and the inhabitants sun themselves in the winter, and where a shrine of Buddha is often erected. The nomadic, cattle-raising Thibetans live in tents, which they weave from the hair of their domestic animals.

The Thibetans are pleasantly disposed, and intercourse with them would be cordial and agreeable were not the free development of their natural traits restricted by the pressure of their religion. Frank and hearty in word and deed and in everything that is not connected with religion, generous in intercourse and in trade with the crafty Chinese, they always come out second best when they have dealings with them. They are brave soldiers and feared as such, but are never cruel. The men are fond of gymnastic exercises, and try their strength together at every opportunity. They are excellent pedestrians and horsemen, and are extravagantly proud if they can boast of having the best horse in the place. As porters they have wonderful powers of endurance. While we Europeans, suffering in the thin air of an elevation of seventeen thousand feet, had to stop often to recover our breaths, I could not but envy our Thibetan bearers, who kept on up the heights with their heavy loads, as often as not singing. Their social intercourse is marked by sharp, sprightly wit and humor; but some of the upper classes ape the artificial courtly manners of the Chinese.

The principal food of the country is called *jamba*. To make it a quantity of powdered tea is cooked for several hours, after which it is poured into a churn, when salt and butter are added, and the whole is stirred till a complete mixture is effected. The broth is then divided among the hungry ones, each of whom gets his share in a wooden bowl, after which a sack of roasted barley-meal is brought out. Every one takes a handful of meal from the sack, puts it into the tea and mixes the mass into a shapely lump, and swallows his dough with a keen appetite. I have seen a Thibetan devour thirty-two of these lumps in an hour. The preparation of this meal makes it possible for each Thibetan to have his hands washed twice a day. After the meal is over, the wooden bowls are licked clean with the tongue, and worn on the breast next to the skin as something precious.

Polyandry is practiced, not on account of any lack of women, for there is no such lack, but as a measure of economy. When the eldest son marries, his wife becomes also the wife of all his brothers. The

custom does not lead to so many difficulties as it might be supposed it would, and the chief troubles arising out of it concern the fatherhood of the children. The housewife occupies rather a commanding than a subordinate position.

Three ways of burying the dead prevail. The poor sink their dead in one of the mountain-streams; those of a better class hang the bodies upon a tree, where they are consumed by birds, and the bones are afterward thrown into the river; the rich cut the bodies up into small pieces, pound the bones and mix them with *jamba*, and then carry the remains to the mountains, where they are left for the birds. These are old customs, and have no connection with religion.

Buddhism was introduced in the seventh century, and soon became the national religion. The present line of Dalai Lamas is in succession to the reformer Tsong-Kaba, who flourished in the fourteenth century, and denounced the corruptions into which the religion had fallen. The branch of the church which it represents is called the yellow sect, in distinction from the red sect of followers of the old dynasty, which prevails in the principalities of the southern Himalaya range. A dynasty of lamas, the Teshu lamas, founded by another reformer in the fifteenth century, resides at Teshulumbo, near Shigatze, and is on the best of terms with the Dalai Lamas. The lamas are believed only to change form when they die, their identity passing to some child. So, on the demise of the Dalai Lama, the new lama is sought out in ways that are known to the priests, and is always found in some obscure family, thus leaving people of any influence always free from governmental care and influence. He is carefully brought up, so as to be always as a child, and under the entire control of the priests, who receive their reward in the power they exercise, and in the rich gifts that are brought by the pilgrims who come from all Buddhist countries to seek the Dalai Lama's blessing. Besides the two orthodox chiefs, there exist in Thibet and Mongolia one hundred and three Kutuktus, or heads of cloisters, to whom an immortality similar to that of the Grand Lamas is ascribed.

The priests, by virtue of their ownership of all the land in the country, exercise a despotic power over the people, who can hold only as their tenants, and keep them under complete spiritual control. They are thus enabled to keep the country isolated, and to defy the Chinese Government, while they are willing and even anxious to enjoy its protection.

SKETCH OF BARON ADOLF ERIC NORDENSKIÖLD.

BARON NORDENSKIÖLD has been styled by Germans the Vasco de Gama of our century. His work is solid and original enough to stand by itself, and need not be compared or contrasted with that of any other. The careful, systematic pursuit of a well-formed purpose, with the full benefit of the experience of past navigators, with a well-defined idea of what was expected to be accomplished, and of how it was to be done, with scientific foresight displayed at every step, can not with justice to either be weighed in the same scale with the bold achievements of the hardy adventurers of former centuries who, starting without the aid of any of the knowledge which has now been accumulated, and without definite notions of where they should go or what they would find, discovered what the fortunes of the wind and the waves brought in their way. The character of Nordenskiöld's work and the manner in which it was performed mark, however, the difference in the methods of research which were available in the past and those which we enjoy and employ at present. In this sense only can a just comparison be made between Nordenskiöld and the explorers of other centuries.

Baron Nordenskiöld is not only a most successful Arctic explorer and navigator, as he is best known: he has done excellent work in other branches of science, and has contributed to knowledge from many directions; and the pages of his narratives of voyages bear evidence to the fact of his versatility, that no event or thing that may add to knowledge is unobserved or unemployed by him; that he knows how to lay all under contribution for the advancement of knowledge. What is most attractive about him, says Dr. Karl Müller, of Halle, "is not the splendid achievement of his polar journeys, but the irrepressible perseverance with which he exerted himself through years at a time to pass from small beginnings to ever bolder and more practical problems. While the navigation of the northeast passage may always be regarded as the brightest among his discoveries, Nordenskiöld was, through all his previous history, a whole man."

Baron Nordenskiöld enjoyed the advantage of an ancestry distinguished through several generations for scientific attainments. "Nature" says, in its biography of the explorer: "The race from which Nordenskiöld sprang had been known for centuries for the possession of remarkable qualities, among which an ardent love of nature and of scientific research was predominant. Its founder is said to have been a Lieutenant Nordberg, who was settled in Upland about the beginning of the seventeenth century. His son, Johan Eric, born in 1660, changed the name to Nordenberg. He died in 1740, leaving two sons, Anders Johan and Carl Frederik, both of whom, though the

latter was only lieutenant, were elected members of the Swedish Academy of Sciences when it was founded in 1739. Carl Frederik is the common ancestor of the families bearing the name of Nordenskiöld now living in Sweden and Finland. One of his many remarkable sons, the third in order, Colonel Adolf Gustaf Nordenskiöld, became owner of Frugord, in Finland. This property, situated in a forest-crowned valley in the department of Nyland, is still in the possession of the Nordenskiölds. Here Colonel Adolf Gustaf Nordenskiöld built a peculiar residence, the middle of which is taken up with a hall two stories high, round the upper part of which runs a broad gallery, in which collections in natural history are arranged. His youngest son, Nils Gustaf, was born in 1792. After passing his examination in mining at the University of Upsala, he was for several years the pupil of Berzelius, with whom he formed the warmest friendship, which was only broken off by death. Nils Gustaf, early known as a distinguished mineralogist, was appointed a government inspector of mines in his native country, and, by means of liberal grants of public money, was enabled to undertake extensive foreign tours, which brought him into communication with most of the eminent mineralogists and chemists of the day in England, France, and Germany. After three years of foreign travel he returned to Finland, and was promoted in 1824 to be chief of the mining department, and devoted thirty years of restless activity to the improvement of that important branch of the industry of his native land. He traveled through Finland in all directions, in the prosecution of his untiring mineralogical and geological researches. His travels extended as far as the Ural. He published his views, discoveries, and experiments in many scientific periodicals and in several independent works, and a large number of minerals discovered by him afford evidence of his keen research. He was made Councilor of State, and obtained many distinctions for his scientific services from the sovereign and from learned bodies. On February 21, 1866, he ended his active life."

Adolf Eric Nordenskiöld, the son of this Nils Gustaf, chief of the mining department of Finland, and of his wife Margaretta Sofia von Haartman, was born at Helsingfors, Finland, November 18, 1832, the third in order of seven children. In his boyhood he was an industrious collector of insects and minerals, and was permitted to accompany his father in mineralogical excursions. Under the guidance of his father, who, a pupil of Gahn and Berzelius, was an expert in those matters, he acquired a skill in recognizing and collecting minerals which proved of great service to him in the path of life he afterward followed, and in the use of the blowpipe. He subsequently undertook the charge of the rich mineral collection of Frugord, and made vacation tours, which were of great benefit to him. He studied for some time with a private tutor, and was then sent to the gymnasium at Borgo, where, according to his own accounts, he enjoyed an almost

unlimited freedom, the teachers showing no inclination to meddle much with the occupations of their pupils. He entered the University of Helsingfors in 1849, and devoted himself chiefly to the study of chemistry, natural history, mathematics, physics, and particularly mineralogy and geology. Having passed his candidate examination in 1853, he accompanied his father on a mineralogical tour to the Ural. In this expedition, according to Professor Fries, of Upsala, was unconsciously laid in him the beginning out of which his later expeditions grew. "It was an instance of the old eagle teaching the young one to fly." After his return from this excursion, Nordenskiöld continued to prosecute his chemical and mineralogical studies with zeal. The subject of his dissertation for the licentiate, "On the Crystalline Forms of Graphite and Chondrodite," which was delivered on the 28th of February, 1855, bore relation to them. During the following summer he was engaged upon a description of minerals found in Finland, which was published in the fall. Various short papers on mineralogy and molecular chemistry were published in the "Transactions of the Finnish Scientific Society," and a paper on "The Mollusca of Finland" was published by Nordenskiöld, along with Dr. E. Nylander, in 1856, in response to a prize question proposed by one of the faculty of the university. While these studies were being prosecuted, young Nordenskiöld had been appointed salaried curator of the mathematico-physical faculty, and had obtained a post at the mining office as mining engineer extraordinary, with inconsiderable pay, and an express understanding that no service would be required from him in return. He lost these positions in consequence of having been present at a festival where too much freedom was given to the expression of political feelings, and spent a few months abroad, working a part of the time at Rore's laboratory in Berlin at researches in mineral analysis. Returning to Finland, he secured a stipend for a line of study through Europe in 1857; but at the "Promotion Festival" in that year, where he was to take his master's and doctor's degrees, more liberal views were aired, which Von Berg, the governor of the Duchy, considered treasonable, and Nordenskiöld left Finland again, this time not to return as a fixed resident. The displeasure of the Government against him was not, however, of long continuance, for he has been welcome in Finland since 1862, and he might have been appointed Professor of Mineralogy in the University of Helsingfors, had he been willing to agree to give up politics. He became naturalized in Sweden, and soon rose to eminence in public life and in science.

The Arctic voyages of Baron Nordenskiöld began in 1858, when he took part in the Swedish expedition to Spitzbergen under Torell, the chief of the Swedish Geological Survey. On his return, he was appointed successor to Mosander in the Riks Museum at Stockholm, where he immediately went to work, partly at the arrangement of the museum, partly at the scientific researches which formed the subjects

of several papers that were published in the "Transactions" of the Academy of Sciences and of the Geological Society. He made constant endeavors to enlarge the collections, with the result that by the aid of the Swedish mineralogists and of the students, who co-operated with him, and in consequence of the extraordinary richness of the Scandinavian Peninsula in rare and valuable minerals, the cabinet has become one of the most considerable in Europe.

In 1861 he took part in the second expedition of Torell to Spitzbergen, expecting with that to end his excursions toward the pole, and with that view married, in 1863, a Finnish lady, Anna Mannesheim, daughter of ex-President Count Carl Mannesheim. He had, however, already, in December, 1862, crossed on the ice from Sweden to Finland, in order to make some investigations on the formation of sea-ice; and in 1864 he went with the third Swedish expedition to Finland, the business of which was connected with the measurement of the arc of the meridian. His destiny to become an Arctic explorer seems to have been settled with this enterprise, and from it may be dated the beginning of a purpose to conduct explorations on his own account and after his own plans. The next year found him engaged in mineral investigations in Sweden and Finland. In 1867 he went to Paris as a member of the International Metric Commission, attended the Exposition, and made the acquaintance of the men of science of the south.

In 1868 Nordenskiöld went out as the head of the fourth Swedish Arctic expedition, to which Mr. Oscar Dickson, the patron of his later voyages, first gave his generous aid. In this voyage he sought to get as near to the pole as possible, and the sensational achievement of it was that the Sophia reached a higher latitude (81° 42′) than had been attained by any vessel in the old hemisphere. Far more scientific importance is attached to the fact that the expedition brought home a rich collection of the fossil plants of the Arctic regions, concerning which but little had previously been known. Another expedition, in which Nordenskiöld was accompanied by Dr. Berggren, was dispatched to Greenland in 1870, having for its principal object to ascertain whether the Esquimau dogs could be relied upon for long sledge-journeys. This question was decided in the negative, but the expedition brought forth scientific fruit second in value to that of no other single one, in that it gave an opportunity to the brave student who led it to examine the remarkable ice-formation of the interior of Greenland, and that it led to the discovery of the celebrated large blocks of meteoric iron of Ovifak, concerning the origin of which a lively scientific controversy has arisen, and which, the explorer himself suggests, may at some future time "form the starting-point for quite a new theory of the method of formation of the heavenly body we inhabit."

Concerning the ice-formation, Baron Nordenskiöld has written:

"An excursion of some length was made into the wilderness of ice, everywhere full of bottomless clefts, which occupies the interior of Greenland, and which, if I except unimportant wanderings along the edge, and an inconsiderable attempt in the same direction in the year 1728, by the Dane Dalager, was now, for the first time, trodden by human foot. I had here an opportunity of clearing up the nature of a formation which, during one of the latest geological ages, covered a great part of the civilized countries of Europe, and which, though it has given occasion to an exceedingly comprehensive literature in all cultivated languages, had never before been examined by any geologist."

Another expedition, of two vessels, was fitted up in 1872, with the design of attempting to reach the pole with reindeers, to which Lieutenant Palander, the companion of his last voyage, was for the first time attached. The ice was unusually unfavorable, and the winter was spent in Mussel Bay, on the north of West Spitzbergen. Here attention was first called to the presence of dust of cosmic origin containing nickel-iron, the agency of which as a possible factor in building up the earth's crust is discussed with considerable fullness in the "Voyage of the Vega"; more complete researches on the aurora and its spectrum were carried on; investigations were made on the development of algæ during the winter night of four months; numerous new contributions to a knowledge of polar countries during former geological epochs were discovered; and a complete series of meteorological and magnetic observations was made in the most northerly latitude where such observations had up to this time been carried on. With this expedition Nordenskiöld's efforts to reach the pole ceased. He had become convinced by his repeated voyages that there was no open sea at the pole; and he had his attention drawn to the "more practical problem, which had interested the foremost commercial states and the most daring navigators for three hundred years, and geographers for thousands of years"—that of forcing a northeast passage to China and Japan, and the circumnavigation of the Old World.

In 1875 he succeeded, with the walrus-hunting sloop Proeven, in sailing over the Kara Sea as far as to the mouth of the Yenisei, whence he put himself in communication with the river-steamers to Yeniseisk; and whence he returned by land, while his companions came back by sea to Europe. By this voyage, he says, "I was the first person who succeeded in penetrating from the Atlantic Ocean in a vessel to the mouths of the great Siberian rivers. One of the objects which the old northeast voyagers had aimed at was at last accomplished, and that in a way that promised to be of immense practical importance for the whole of Siberia. The voyage was also regarded in that light by leading men of the great empire of the East, and our return journey from Yeniseisk by Krasnojarsk, Tomsk, Omsk, Yekaterinburg, Nizhnee-Novgorod, Moscow, and St. Petersburg became, therefore, a jour-

ney from *fête* to *fête*. But a number of voices were simultaneously raised, which asserted that the success of the Proeven depended on an accidental combination of fortunate circumstances which would not soon occur again. In order to show that this was not the case, and that I might myself bring the first goods by sea to Siberia, I undertook my second voyage to the Yenisei in 1876, in which I penetrated with the steamer Ymer, not only to the mouth of the river, but also up the river to Yakovieva in 71° north latitude. Hence I returned the same year by sea to Europe."

Between these two voyages, Baron Nordenskiöld found time to visit our International Exhibition at Philadelphia, in connection with which his name is recorded as one of the judges in the group of pottery, glass, artificial stone, etc., and as an exhibitor of maps. "And it may deserve to be mentioned," he says, "that, leaving New York on the 1st of July by one of the ordinary steamers, and going on board my own vessel in Norway, I reached the mouth of the Yenisei on the 15th of August—that is to say, in forty-six days."

The voyages of the Proeven and the Ymer led to several purely commercial voyages to the Yenisei and the Obi. After his return from the second voyage, he became fully satisfied, in the light of his own experience and of the old explorations of the north coast of Asia, that the open navigable water, which for two years in succession had carried him across the Kara Sea, formerly of so bad repute, to the mouth of the Yenisei, extended in all probability as far as Behring Strait, and that a circumnavigation of the Old World was thus within the bounds of possibility.

He conceived the idea of a new voyage, the purpose of which was to pass through the whole extent of the Arctic Ocean to Behring Strait, and thence around the continent back to Stockholm. He solicited an audience with the king, the scientific men, and Arctic voyagers of the country. It was given him on the 27th of January, 1877, and he came to it fully prepared with a statement of his purposes and his reasons for considering them feasible. Besides "the world-historical navigation problem," which would be solved by the success of the enterprise, he suggested that "extensive contributions of immense importance ought also to be obtainable regarding the geography, hydrography, zoölogy, and botany of the Siberian polar sea; and beyond Behring Strait the expedition will meet with other countries having a more luxuriant and varied nature, where other questions which perhaps concern us less, but on that account are not of less importance for science as a whole, will claim the attention of the observer and yield him a rich reward for his labor and pains."

He received the encouragement and aid he asked for, and was able to sail in July, 1878, on a new expedition, the complete success of which is a matter of history, and the ultimate results of which, in the opening of new branches and lines of trade, and the bringing to pos-

sible productiveness of an immense region hitherto supposed to be consigned to the dominion of ice, can not as yet be adequately estimated.

The value of his work was appreciated by the people with whom he came in contact during the course of the voyage. On the arrival of the expedition of 1875 at the Lena, the Dolgans at that remote spot on the border of the tundra, "when they understood clearly that we had come to them not as brandy-sellers or fish-buyers from the south, but from the north, *from the ocean*, went into complete ecstasies . . . . At Dudino, also, the priests living there held a thanksgiving service for our happy arrival thither." The voyage home, around the Pacific coast and by the Indian Ocean and Suez Canal, was marked by a series of festivities given at every point where the Vega touched. At Yeddo the navigators were greeted with deputations, bearing addresses of welcome and invitations, and were given a lunch with the Mikado, and a special audience with his Majesty. Similar scenes were repeated, with such variations as circumstances made appropriate, at Hong-Kong, Cairo, Naples, Lisbon, Paris, Copenhagen, and Stockholm. At Naples, the expedition was welcomed back to Europe by the representative of King Oscar of Sweden, who also conferred Swedish decorations on Baron Nordenskiöld and Lieutenant Palander; an Italian officer came down from Turin commissioned by the Government, and bearing the welcomes of several municipalities and scientific societies, with Italian orders for the men of the Vega. At Lisbon, in addition to the usual audiences and receptions, the Portuguese Chamber of Deputies voted a welcome and a congratulatory address. Circumstances prevented the public demonstrations which had been arranged for in England from being held, but the visit of Nordenskiöld and Palander to London was made pleasant by the hospitality of the most distinguished scientific men of the kingdom. At Paris a public reception was given by the Geographical Society; the commanders' and officers' insignia of the Legion of Honor were conferred by the Minister of Education, at a meeting of the delegates of twenty-eight learned societies held in the Sorbonne; a welcome was given by the Institute followed by a festive reception by the Municipal Council; numerous dinners were eaten, and medals were liberally distributed. Invitations to Holland and Belgium had to be declined "from want of time and strength to take part in more festivities." The entrance to Stockholm was made through a thick fleet of excursion-steamers gayly decorated, and under a brilliant illumination of the city; and, after the first enthusiastic welcomes, "*fête* followed *fête* for several weeks." Writing of this expedition, Dr. Karl Müller says, in "Die Natur," that "among the most recent voyages none has been so splendidly planned, none undertaken with such noble means and pursued with such eminent scientific success as the circumnavigation of Europe and Asia by Nordenskiöld

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and his companions." Of the series of voyages to Spitzbergen, "Nature" says: "These expeditions were not undertaken for the mere purpose of creating a sensation by the foolhardy feat of attempting to reach the pole at all hazards. Geographical discovery certainly formed a part of the programme of all the expeditions in which Nordenskiöld has been engaged;" and it contrasts the results—of the first importance, and obtained with a modest expenditure—strongly with those of "the expensive and elaborately equipped expedition in the Alert and Discovery." Speaking in 1879, while the last expedition was still in progress, "Nature" said, "Comparatively young as Professor Nordenskiöld is, he has done an amount of work rarely accomplished even in a long life-time." And in February of this year, reviewing his whole work, it said: "Thus no one man has done half so much as Baron Nordenskiöld for a scientific exploration of the Arctic regions. The most striking characteristics of his various expeditions have been the small expense at which they were conducted, their modest but carefully considered equipment, the clear and scientific methods on which they were planned, and the wealth and high value of the results obtained." Baron Nordenskiöld is now preparing for another expedition.

Baron Nordenskiöld represented the capital of Sweden in the Diet from 1869 to 1871, and was instrumental in bringing about some important legislative measures for the promotion of science.

Personally, Baron Nordenskiöld is a genial man. His modesty and aversion to public display, which are well known and recognized, are quite remarkable in his "Voyage of the Vega," where he shuts his personality wholly out of sight, and devotes his attention, with an exclusiveness which is rare among travelers, to the account of what he observed and learned. Yet he loses no occasion to introduce his companions and their labors, and to give them full credit. So complete is his sinking of himself that it has been impossible to find anything in that work with which to illustrate his personality for the purposes of this sketch.

ENTERTAINING VARIETIES.

—— Says "Blackwood's Magazine": "The man who first suggested an electric telegraph, in a letter to the 'Scots Magazine' in the year 1745, Charles Marshall, was looked on as having dealings with the Evil One, and had to leave his native country and go to America. When Ronalds, about the year 1817, laid his plans for an electric telegraph before the English Government, they would not even take the trouble to investigate the matter. An under secretary, in the usual official style, wrote him that he was 'directed by his Majesty's Secretary of State, etc., to inform Mr. Ronalds that a telegraph is of no use in time of peace, and that in time of war the semaphore then in use was quite sufficient for the purpose.'" And as late as 1879 one of the "most able and experienced electricians of the day" was in a state of mind to say before a select committee that he did not think the telephone would be much used in England; that he fancied the descriptions they got of its use in America were a little exaggerated; "but there are conditions in America which necessitate the use of instruments of this kind more than here. Here we have a superabundance of messengers, errand-boys, and things of that kind. In America they are wanted."

—— *Tanner*, in his narrative of a captivity among the North American Indians, says that, when a certain chief named Picheto was one night much alarmed by a furious storm, he got and offered some tobacco to the thunder, entreating it to stop.

—— *Prisons as Clinics.*—Dr. Maudsley remarks: "Another promising but strangely neglected field of inquiry is a study of *criminals.* The time will come, ought to have come now, when prisons shall be used for the systematic investigation of the antecedents, and for the clinical study of the varieties of the criminal nature, just as asylums are used for the clinical study of diseased minds, hospitals for the study of diseased bodies. It may not be doubted whether half the books that have been written on moral philosophy would be worth one good book, by an earnest and industrious inquirer, who should undertake the scientific study of the inmates of a single prison."

—— *Max Müller* says, in his sketch of *Kant*, that for the last twenty years of his life he always had guests at dinner—two to five—that he demanded punctuality, that the guests proceeded to the dining-room talking of no subject more profound than the weather, that politics (and we may add science, natural history, etc.) was a frequent subject of conversation, but anything of the nature of metaphysics was rigorously excluded. Though of a very slender constitution, all his life through Kant had managed to keep himself in health by persistent adherence to certain maxims of diet and regimen. One of these was that the germs of disease might often be avoided if the breathing were systematically carried on by the nose; and for that reason Kant always in his later years walked alone with mouth closed. He was also careful to avoid perspiration. He walked after dinner alone, and then attended to business or read newspapers and miscellaneous books. As the darkness began to fall, he would take his seat at the stove, and, with his eye fixed on the tower of Lobenicht church, would ponder on the problems which exercised his mind. One evening, however, as he looked, a change had occurred—the church-tower was no longer visible. His neighbor's

poplars had grown so fast that at last, without his being aware, they had hid the turret behind them. Kant, deprived of the material support which had steadied his speculations, was completely thrown out. Fortunately, his neighbors were generous—the tops of the poplars were cut, and Kant could reflect at his ease again.

—— The manuscript of Mill's "Logic" was first sent to the publisher Murray, who, after keeping it so long as to occasion a year's delay in its publication, declined it. It was next offered to Parker, who accepted it, and sent the opinion of his referee, in the writer's own hand, withholding the name. "He forgot," said Mill, "that I had been an editor, and knew the handwriting of nearly every literary man of the day." The referee was Dr. W. Cooke Taylor, who afterward was one of the reviewers of the book.

—— *Carriage-Fares in New York and London.*—A writer in the "Tribune," describing the carriage system of large cities, says: "Briefly put, the legal rates for cabs and carriages in New York are fifty cents a mile and fifty cents a half-hour, with no fare less than one dollar. In London the cab rate is twenty-five cents for any distance under two miles, and thirteen cents for each additional mile; just one fourth the rate in New York." Who would live under monarchical extravagance, when they can have republican simplicity at four times the price?

—— *Infinitesimal Scale of Molecular Systems.*—Life is a stream of attributes that flows along from generation to generation, each kind being, as it were, a special channel for special characters. But the everlasting wonder is, how all the characteristics of a species can be embodied in a germ so as to be reproduced by growth; and still more amazing is it how the nicer shades of organic modification are also transmitted by the germ so as to become hereditary. In some way the systems of organic molecules must be capable of taking and retaining an infinite number of inconceivably delicate impressions; for with the myriad forms of life there must be formed myriads of molecular modifications of germ structure. Dr. Flint says that the head of a human spermatozoön is $\frac{1}{5000}$ of an inch long, $\frac{1}{8000}$ of an inch broad, and $\frac{1}{25000}$ of an inch in thickness; and Professor Du Bois-Reymond says if this head is assumed to be as large as the Great Eastern, and packed throughout with machinery as fine as the finest ladies' watch, even this would fail to represent the fineness of the system of molecular machinery that actually fills the head of the real spermatozoön.

—— According to *Mr. Lockyer*, the Egyptians are stated to have recorded 373 solar and 832 lunar eclipses; and he says this statement is probably true as the proportions are exact, and there should be the above number of each in from twelve hundred to thirteen hundred years.

—— The "Saturday Review" notices, as an instance of the reduction to absurdity of the conjectural method, the efforts of M. de Gubernatis to interpret the multiform stories of the cat and allusions to the cat in folk-lore, as parts of the great system of solar myths. With M. de Gubernatis, the cat with white ears in a fairy tale is the "morning twilight," or 'the moon which chases the mice of night." A chattering cat appears in a Russian fairy story, and is killed in the territory of a hostile sultan. M. de Gubernatis explains that the sultan is "the wintry night," but leaves us in the dark as to what the chattering cat is. A cat is metamorphosed in a tale by Madame d'Aulnay into a woman who wears a dress of thin white gauze, set off with rose-colored taffeta, the gauze and rose-colored taffeta being inventions of the author's fancy which she has added to the

original story. M. de Gubernatis does not see them in this light, but regards them as something highly mythical, and as signifying that the white cat was the moon, and became the dawn. So in Æsop's fable of the cat-woman, that the bride went to bed must mean that "the evening aurora sinks into night." "The Italians describe an empty house by saying, 'There was not even a cat there.' But do they mean that the house is deserted, even by the home-loving, domestic puss? Nothing so commonplace. The proverb is derived from the sun entering the night, where he finds nothing, or 'only the cat moon.' Black cats are not black cats, but they are the moonless night. 'The cat in the bag of the proverb has probably a diabolical allusion!' When a German invalid sees two cats fight, he thinks it a bad omen. Why? Because, in M. de Gubernatis's opinion, the cats 'represent, perhaps, night and twilight.' It seems to be held that men take no interest in anything except so far as it may be considered a symbol of night or light. When *montes parturiunt*, and *nascitur ridiculus mus* (the mountains labor and a ridiculous mouse is born), the reference is not to the immensity of the labor and the minute results. Oh, no; 'from the mountain came forth the mice of night, the shadows of the night, to which the cat moon and cat twilight give chase.' . . . 'When the cat's away the mice will play.' What does this mean? It means that 'the shadows of night dance when the moon is absent,' which is precisely what they do not do. No moon, no shadows, still less any shadow-dance. The most ordinary truths of experience are not only set aside, but reversed, by the method of M. de Gubernatis, a method from which not even poor puss has escaped."

—— Baron von Nordenskiöld, in his "Voyage of the Vega," gives a pleasant account of the domestic life of the Chukches, the tribe that inhabits the northeasternmost part of Asia. "Within the family," he says, "the most remarkable unanimity prevails, so that we never heard a hard word exchanged, either between man and wife, parents and children, or between the married pair who own the tent and the unmarried who occasionally live in it. The power of the woman appears to be very great. In making the more important bargains, even about weapons and hunting implements, she is as a rule consulted, and her advice is taken. A number of things which form women's tools she can barter away on her own responsibility, or in any other way employ as she pleases. When the man has by barter procured a piece of cloth, tobacco, sugar, or such like, he generally hands it over to his wife to keep. The children are neither chastised nor scolded; they are, however, the best behaved I have ever seen. Their behavior in the tent is equal to that of the best brought-up European in the parlor. They are not, perhaps, so wild as ours, but are addicted to games which closely resemble those common among us in the country. Playthings are also in use, for instance dolls, bows, windmills with two sails, etc. If the parents get any delicacy they always give each of their children a bit, and there is never any quarrel as to the size of each child's portion. If a piece of sugar is given to one of the children in a crowd, it goes from mouth to mouth round the whole company. In the same way the child offers its father and mother a taste of the bit of sugar or piece of bread it has got. Even in childhood the Chukches are exceedingly patient. A girl who fell down from the ship's stair, head foremost, and thus got so violent a blow that she was almost deprived of hearing, scarcely uttered a cry. A boy, three or four years of age, much rolled up in furs, who fell down into a ditch cut in the ice on the ship's deck, and in consequence of his inconvenient dress could not get up, lay quietly still until he was observed and helped by one of the crew."

EDITOR'S TABLE.

DU BOIS-REYMOND ON EXERCISE.

MAGAZINES are of two kinds: the entertaining kind, which cater to mental laziness, and can be skimmed over without mental effort; and the instructive kind, which contain articles that must be read twice. "The Popular Science Monthly," from the start, has furnished a considerable proportion of articles so weighted with valuable thought as to require concentration of mind and often careful reperusal to grasp and assimilate their contents. This has provoked frequent protests on the part of our readers, who have complained that we deviate from the magazine-standard of easy reading, and are not true to our title, which promises a magazine adapted to the populace. Yes, but to the *improvement* of the populace! The "Monthly" was started for no other reason than because the standard of our current magazines was low—too low to reflect the best mental activity of the times. Their aim is to amuse and beguile their readers by calling forth the smallest possible amount of mental reaction. We started because the popular magazines, competing downward, shirked vigorous work, and were false to the demands of an age characterized beyond all others for its intellectual seriousness, and by the magnitude, importance, and practical quality of the questions that are occupying the ablest minds in all countries. These minds can not be followed—these questions can not be understood—without effort on the reader's part. This is the price that must be paid for real knowledge. People can not be amused into mental grasp and vigor, they must be *exercised* into it. We talk of mental progress, mental elevation, mental expansion, but these are attainable only on the condition of mental exertion.

We print, in two parts, another of those articles that have to be re-read to get their full import. It is by Professor Du Bois-Reymond, and is on "Exercise," so that it is at the same time an illustration and an exposition of our subject. It is a most original and instructive statement, and will well repay reperusal.

One of the inevitable effects of the advancement of science in various directions is the establishment of new connections of thought which are often most striking and significant. What can Darwinism have to do with exercise? Restricting the term Darwinism, as we must do, to natural selection, Du Bois-Reymond shows that they are very closely related. Viewing organic nature mechanically, the series of living beings has been unfolded during unlimited time by adaptation to new conditions, the course of movement being in an ascending scale. "From this point of view, organic nature appears not only as a machine, but also as a self-improving machine." But the law of self-improvement is, that powers and faculties are strengthened and grow by exercise, and are weakened by non-exercise. In the struggle for existence, therefore, those will win and survive in whom exercise has developed superior capacities and resources, while the less exercised and weaker fail and perish. The principle of exercise is thus a kind of motive-power in animal evolution, and, as might be expected, is full of the most important results in the higher spheres of physiological and psychical activity.

The predominance of pugilism and athletic sports, which depend upon "muscle," have favored the idea that the chief influence and benefit of exercise is upon the muscular system; but Professor Reymond shows that this is an error. An important effect is, of course, produced in the development of the muscles, which is very fully and interestingly traced out; but by far the most important and valuable influence of physical exercise is shown to be upon the nervous centers. "It is easy to show the error of the common view, and demonstrate that such bodily exercises as gymnastics, fencing, swimming, riding, dancing, and skating are much more exercises of the central nervous system, of the brain and spinal marrow. Every action of our body as a motive apparatus depends not less but more upon the proper co-operation of the muscles than upon the force of their contraction. In order to execute a composite motion, like a leap, the muscles must begin to work in the proper order, and the energy of each one of them must increase, halt, and diminish, according to a certain law, so that the result shall be the proper position of the limbs, and the proper velocity of the center of gravity in the proper direction."

But when it is established that the central nervous system is not only amenable to the law of exercise, but is the chief object of its influence, we then begin to see how the highest mental effects are involved in the question. Improvement by means of exercise and deterioration from non-exercise apply to the gray matter of the brain as well as to the muscles. From this point of view, which is that of the philosophy of human educability, the subject has a comprehensive interest, and we hope our readers will recognize that, in furnishing them articles that imply some effort in their mastery, we are conforming to the only law by which real mental improvement can be secured.

MORE SIGNS OF THE TIMES.

THAT there has been going forward within the last few years a rapid liberalization of public opinion on the subjects that are in issue between science and theology, everybody now admits; and, having done what little we could to promote this salutary result, we are naturally interested in all the striking indications of the growth of toleration in quarters where it has been previously but little looked for. We called attention a few months ago to the significance of a declaration made by an eminent English doctor of divinity that the appreciation of Herbert Spencer's system of philosophy is "an education to an age," and we have now to take note of another liberal concession of perhaps greater interest.

The Victoria Institute, a vigorous English society of nearly a thousand members, consisting chiefly of lords, bishops, and clergymen, was founded a few years ago for the broad purpose of reconciling orthodox Christianity with the revelations of science. It is a kind of British standing committee on the relations of science and theology, the duty of which is to consider and report on all the alleged cases of their conflict.

It has been long expected that the Institute would take up the question of the religious relations of Spencer's philosophy, and that has now been done. The last report of its proceedings, just published, contains an elaborate paper, attacking this system and claiming to demolish it, which was written by the Rev. W. D. Ground, and its reading was followed by an unusually full discussion of the subject by the members of the Institute. We have no room to reproduce at length either the essay or the comments that were made upon it; but there are certain features of both to which it seems desirable to call attention, because we here get weighty theological confirmation of positions that

have long been maintained in the Popular Science Monthly."

We have heard a great deal of Mr. Spencer's materialism. The charge has become stereotyped. It is said that this is a materialistic age; that life is materialistic; that science is materialistic, and that Spencer is the arch-materialist who works the doctrine up into a philosophy for universal gratification. We have always denied the truth of this accusation, and held that it has been made either in ignorance or dishonesty. We have maintained not only that Spencer is explicitly opposed to materialism, but that he has written with great power against it. And we have, moreover, maintained that, in the future emergencies of theological thought which are sure to result from the further progress of science, the value of Spencer's anti-materialistic logic will be better appreciated. All this has been regarded as sufficiently amusing, but how is it now with the experts of the Victoria Institute? The Rev. Mr. Ground says: "The existence and the immateriality of mind is a cardinal doctrine of Mr. Spencer's philosophy. It is one of the last and most certain deliverances of his philosophy that mind and matter both exist, and that between these two there is a chasm which no effort of ours enables us to cross. He exhausts the resources of language to declare that this is the one fact which transcends in absolute certainty every other fact. Somehow, this seems to have escaped the notice of many who have criticised his writings, and he is commonly believed to uphold something like materialism. Greater error, however, there can hardly be. Materialism has never before had such a powerful and uncompromising opponent, and it is hardly probable that it can ever again make head against his attacks. The doctrine of the absolute immateriality of mind is a structural part of his philosophy, and one which is simply invaluable to those who see the spiritual aspect of things."

In the discussion which followed the reading of the paper, there was not a word of protest against this statement. Various things were objected to, but this avowal, so directly in the teeth of current prejudice, provoked not the slightest criticism. It was, in fact, indorsed by the unanimous approval of Mr. Ground's argument, which was based upon the idea that Spencer is not a materialist, and derived its whole force from this assumption. Mr. Ground makes numerous citations from Spencer which incontestably prove his position; and this portion of his argument may be fairly put against the whole mass of criticism which aims to convict Spencer of materialism.

But there was one part of Mr. Ground's essay for which the society was not prepared: his estimate of the character of Spencer's work startled his audience. He began by saying: "The system of philosophy associated with the name of Herbert Spencer has now been nearly twenty years before the philosophical world, and it has slowly made its way until it has won a place in the first rank of such productions. Whatever we may think of it, it is not easy to withhold our intellectual homage. It is the last and probably the greatest attempt ever made to present a true philosophy of the kosmos; it is imbued with the modern scientific spirit; it claims to be strictly in accord with scientific principles; it displays a breadth of generalization and a wealth of energy such as we find only in the greatest works of all time; and it is by many believed to be one of the worthiest triumphs ever achieved by the unaided intellect of man. It is never easy to estimate justly any contemporary work—we stand too near it to see its true proportions—but it seems to not a few that Mr. Spencer may fairly claim a place in the front

rank of the intellect of the world. His greatness in this respect must in justice be conceded."

Mr. Ground in closing re-affirmed his high opinion of the import of Spencer's work as follows: "We may, however, allow that, if only he will keep within his proper limits, very much of what he has written will stand in lines of unfading truth and beauty, and he will have the honor of lifting the human intellect to a higher plane of thought and life. He is so great and many-sided, and he has contributed such a vast amount of intellectual force, that no one who reverences the mind of man as one of the greatest handiworks of God can honestly refuse him homage. He stands before us of the build of the giants, perhaps of the immortals, and his nature is not yet made up so as to show us what will be his ultimate place—whether amid those who shed kindly benefactions on the race, or those who like evil angels leave behind them a heritage of negation, unbelief, and despair."

Such talk was not at all palatable to the members of the Victoria Institute, who could not recognize much greatness in a man whom they had just seen so effectually "crushed." The chairman led by observing, "I would rather not have seen so very much admiration for Mr. Herbert Spencer combined with the reasoning of the paper, which proves so successfully that if this 'writer' is indeed a 'gia t,' he is but a giant stuffed with straw." The Rev. Dr. Irons remarked, "I concur fully with the chairman in saying that the estimate formed of Mr. Herbert Spencer was somewhat exaggerated, and yet I have to acknowledge the great admiration I entertain of Spencer's style and acuteness and power of analysis, and I do not think we gain anything by depreciating our opponents." Others followed in a similar strain, and only Professor Griffiths accepted the estimate of Spencer, and took exception to the general argument of the essay. In reviewing and closing the discussion, Mr. Ground admitted that he might have been over-impressed by Spencer's genius, but that it was very easy to commit the opposite mistake. He said: "I feel sure, however, that some in this Institute greatly underrate Mr. Spencer—a mistake which in my judgment would, if not corrected, bring disastrous consequences, but it is possible that I may have gone to the opposite extreme. In reading his philosophy, I am distinctly conscious that vaster thoughts are before me than when reading Shakespeare. Shakespeare one can take up any time as the companion of an idle hour, and the amount of mental stimulation he gives is relatively trifling. Not so is it with Spencer. It is only when the eye is keenest, the will strongest, the nervous force most abundant, that you can be sure of following him. The first (Shakespeare) carries you through the gentle undulations of an English county, and his highest elevations are hardly so much as Snowdon or Helvellyn, but Spencer carries you up the awful Alpine ranges, where the spaces of thought over which the eye roves are incomparably vaster, and where the exertion demanded is far greater. Spencer has a certain Miltonic grandeur. I could name places in his philosophy where views are given us of creation, in which, if we add the spiritual conceptions of which I spoke, the idea presented rises, to my mind, in extent, sublimity, and overpowering greatness above everything I have yet met with in all uninspired literature. To grasp his system is like standing in the Sistine Chapel and bearing the full weight of the conceptions of Michael Angelo. While this fact explains the fascination that Spencer exerts over many, it also shows us the great danger either of letting his system continue, as it no doubt is, the reigning philosophy of the world, or of depreciating it below its just value."

THE SLOW PROGRESS OF IDEAS.

In his recent excellent report to Columbia College, Dr. Barnard says, in discussing the policy of universities, "Newton stands perhaps without a peer in the scientific annals of all time, yet the astronomy of Ptolemy continued to be taught in Newton's own university of Cambridge for a century after the publication of the 'Principia' had created astronomical science anew." This is an excellent illustration of the power of habit and tradition in education. In further discussing "Education as a Science" in the same report, President Barnard quotes the following statement of the Rev. Mr. Quick, the Cambridge lecturer, on the history and philosophy of teaching: "I take it that Jacotot taught more emphatically than any one three great pedagogic truths: first, that a good teacher exercises the searching rather than the receiving faculties of the learner's mind; second, that all fresh knowledge should be connected with what the learner knew before; and, third, that a thorough knowledge of anything is an almost inexhaustible source of power. However, if his principles were right, there must have been some grave defect in the application of them, or his system, which at first met with immense success, would not so speedily have lost its ground." To this President Barnard adds, "The grave defect in the application consisted obviously in his pushing the first principle to an extravagant and unreasonable excess, and in leaving the pupil too entirely helpless."

We suspect that the reason why those golden truths of Jacotot have not been more generally accepted and practiced, and why his system perished with him, was deeper than is here indicated. Badly applied they no doubt were, but it is more significant that they were prematurely thoroughgoing, and involved the cutting up of an old system, root and branch. If it took a hundred years for the magnates of Cambridge University to recognize the demonstrated truths of the "Principia," how much longer will it take to introduce something like a law of gravitation into education? It is hurrying things if a great new principle gets well accepted in a century and intelligently applied in another century, and Jacotot's experiment is but half a century old. Science is making progress, but it moves precious slow in old educational establishments. Loading the memory with Greek and Latin seems still to be the leading business of Columbia College; while Dr. Barnard tells us that "zoology, botany, physiology, and biology are all unrepresented in our scheme of instruction." As a further illustration of the slowness of collegiate improvement and reform, it may be mentioned that, while Columbia College has a strong corps of teachers for drilling in the dead languages, it has no adequate provision for discipline in the correct and elegant use of the living language in which the intellectual life-work of all the students is to be carried on. Dr. Barnard laments that there is no sufficient provision "to practice the learner in the proper use of language," and urges the Board of Trustees to repair this and the other omissions referred to. From all of which we infer that, although knowledge goes slow, Columbia College goes slower.

Dr. Barnard desires to have the ladies patronize his institution, but they may well reply: "Not yet, dear doctor; you are too far behind the age. We appreciate the honor, and the society of the gentlemen would not be unpleasant; but it is a very important question whether the culture you are prepared to give us is the best calculated to qualify us for that sphere of life to which most of us are destined. We have all read that Agesilaus, King of Sparta, upon being asked what things he thought most proper for girls to learn, answered, 'Those which they

ought to practice when they come to be women.' Does your education answer to that test? Is a college in which physiology and biology are unrepresented, and which offers no instruction in anthropology—the science of human nature—the proper place to educate young women for the duties of motherhood, the nurture of children, and the intelligent practical administration of home affairs? We can not see that you have what we most want, and we are afraid if we came you would so fill our heads with everything we don't want that we should be worse off than if we were not educated at all. Go on with the excellent work of modernizing your curriculum, and, when you have made it to better represent the present state of knowledge, it will be time to talk to us about buying it."

This is encouraging. We had supposed that the ladies were crazy to get into the college anyhow, without the slightest regard to what they found there—in fact, wanted to get in merely because they had been kept out; accordingly, as this is not so, we rejoice.

COLLEGE GOVERNMENT.

We last year had the pleasure of commending the new departure of Amherst College in the matter of government. It consisted in an open repudiation of the old and still prevailing system of paternal control which so naturally engenders conflict and promotes excesses on the part of the students. As we before remarked, young men can only be educated in manhood by being practiced in its liberty and responsibility. The home government of childhood and early youth is necessarily paternal, watchful, care-taking, often too much so for the development of self-reliant character; but when boys become young men they have the right to substitute self-restraint for external restraint as the governing law of conduct. And especially when they go to college, where the scheme of studies assumes mental maturity, where the new social forces are so active, and the new temptations so strong, they should be thrown upon their honor, and pledged to self-control at the outset and without reserve. It is gratifying to observe that the second year's experience at Amherst proves the practicability and the superiority of the self-governing method. A correspondent of the "New York Evening Post" remarks:

It has been a year of unusually satisfactory progress. Professor W. S. Tyler, who was graduated in 1830, and has been connected with the college ever since, says that it has been the most healthy and satisfactory year for the college that he has ever known. More and better work has been done in the studies, and there has never been a year of such perfect discipline. It is the new system of government, now at the end of its second year of practical working, which is given the credit of the improvement. In brief, the system is this: The relation of faculty and students is regarded as that of two parties to a contract. The student wishes to study, and contracts to follow the rules of the college. The faculty contract to give the instruction. If a student breaks his contract by disorderly conduct or by committing any of the irregular acts so common in colleges against public peace, he is held to have broken his contract, and *ipso facto* his connection with the college ceases. He has broken his word, and a rupture of the contract by one party releases the other. No vote of expulsion is passed. There is no writing home to parents. No member of the faculty is expected to act the spy. The single act of the student settles the whole thing. All this is now perfectly understood. When the system was introduced its first enforcement was particularly severe, and the students did not fully comprehend the situation. For that once only, after a full reparation for the wrong, the offenders were restored to their standing, and there has been no relaxation of the rule since. It was believed that the past year would be particularly trying, because the novelty would be worn off, and the permanent value of President Seelye's theory would be tested. Besides this change, there came with it a total abolition of the old ranking system, and so the test this year has been particularly severe. It is of high interest, therefore, that every one of the faculty, and, so far as is

known, every one of the students, is heartily in favor of the new system. Not a single disorder has occurred in college during the year. Even the freshmen, to burn their celebration bonfire, did not steal any one's fence, nor tear down any one's barn, but bought their materials and had an honest fire on the campus. A spirit of manliness and self-reliance has become prevalent to a degree which was utterly unknown when the students were under the parental system, and were inclined to regard the faculty as their natural enemies. About a fortnight ago the faculty made a thorough investigation into the scholarship in all departments, in order to compare the efficiency of the course now with what it was under the old method of discipline and working. It was found that the new way is better than the old by far, and that the scholarship of the students is better than formerly. This is not attributed to any higher average in the general ability of the young men, but solely to the stimulus which comes from the college atmosphere.

LITERARY NOTICES.

INTERNATIONAL SCIENTIFIC SERIES, NO. XLII.

ANTS, BEES, AND WASPS. A Record of Observations on the Habits of the Social Hymenoptera. With Illustrations and Colored Plates. By Sir JOHN LUBBOCK, Bart., M. P., F. R. S., etc. D. Appleton & Co. Pp. 448. Price, $2.

WHEN, some ten years ago, the author of this work was solicited to contribute a volume to the "International Scientific Series," he cordially consented, on the condition that he might take his time. Nothing could be more reasonable, for Sir John is a very busy man, and occupied by many duties. But, now that his book has appeared, the surprise is that he should have done it so quickly. The most expeditious way of producing a book is, of course, with the scissors; the next is with the pen, where the work is spun from the fancy; but the slowest method is where the author strikes into original inquiry, which involves long-continued observation and experiment before he can bring the subject into shape for literary presentation. It is in this sense that Sir John Lubbock has *made* the present work. How it has originated, and what is its object, are thus stated in the preface: "This volume contains the record of various experiments made with ants, bees, and wasps, during the past ten years. Other occupations, and many interruptions, political and professional, have prevented me from making them as full and complete as I had hoped. My parliamentary duties in particular have absorbed most of my time just at the season of year when these insects can be most profitably studied. I have, therefore, whenever it seemed necessary, carefully recorded the month during which the observations were made, for the instincts and behavior of ants, bees, and wasps are by no means the same throughout the year. My object has been, not so much to describe the usual habits of these insects, as to test their mental conditions and powers of sense."

The work has, therefore, a twofold interest. In the first place, it is a contribution to comparative psychology; a subject which requires much more cautious and discriminating study than it has formerly received. The insects to which Sir John Lubbock has devoted himself exhibit remarkable mental traits, but it is by no means so easy a thing to interpret them rightly. Much, of course, was critically and accurately known of their habits and characters before our author took up the inquiry, as his copious bibliography and numerous citations show; but there was also so much loose and exaggerated statement in the popular natural history of these creatures, and so much serious deficiency in their scientific study, that a close and systematic re-examination of the phenomena was necessary. Sir John devised various ingenious methods of dealing with his insects, and by taking the ample time necessary to educate himself in their manipulation, and in getting familiarly acquainted with their ways, he has been enabled to qualify many previous opinions respecting their intelligence, and very much to extend our accurate knowledge upon the subject.

But while the problems which Sir John Lubbock had here to solve were those of comparative psychology, they have another interesting aspect. The insects being gregarious and eminently social, all their mental manifestations were in social relation, so that the inquiry ran inevitably into comparative sociology. It is this fact which gives

the highest interest to the research. It is of no little importance to find out how much these tiny creatures *know* which are capable of elaborating such curious and extensive social arrangements. Are they really next to man in the scale of intelligence? Sir John Lubbock seems to have arrived at this conclusion, but he opens his introductory chapter thus: "The anthropoid apes no doubt approach nearer to man in bodily structure than to any other animals; but when we consider the habits of ants, their social organization, their large communities, and elaborate habitations; their roadways, their possession of domestic animals, and even, in some cases, of slaves, it must be admitted that they have a fair claim to rank next to man in the scale of intelligence."

We have no space either to explain Sir John's interesting method of procedure in these researches, nor to intimate his results. But we may say that the author has thoroughly caught the spirit of his country neighbor, Mr. Darwin, and that his book is quite of the Darwinian order, evincing the most minute, painstaking, and patient observation, and reasoning no further or faster than the facts will warrant.

CAPITAL AND POPULATION: A STUDY OF THE ECONOMIC EFFECTS OF THEIR RELATIONS TO EACH OTHER. By FREDERICK B. HAWLEY. New York: D. Appleton & Co. Pp. 267.

THE author confesses his position, as exemplified in his treatise, to be a peculiar one. While considering himself a disciple of what is called the English and orthodox school in political economy, he has arrived at results which are in many instances diametrically opposed to those of that school; especially on the subjects of free trade and taxation. On the other hand, his reasoning presupposes the falsity of most of the arguments heretofore advanced in support of the very conclusions he upholds. These singular results are obtained by his taking up the reasonings of Mill and Ricardo, and others of their school, and carrying them out on their lines beyond the limits where they stopped, and by taking up and giving importance to factors that were unconsidered or overlooked by them. Having pointed out an important variation in the definition of capital as given by Ricardo and Mill, he makes the deduction that over-accumulation, or the increase of capital beyond the needs of population, is not only possible, but of frequent and periodic occurrence in all civilized nations; that there is, in fact, a tendency to it. He then undertakes to show that proportional and real wages vary inversely instead of together, as has heretofore been assumed, and that it is not a high rate of proportional wages, but of real wages, that is a stimulus to population. He further reaches conclusions opposed to free trade and in favor of the protective policy; that manufactures are more advantageous as a national pursuit than agriculture, and commerce is more advantageous than either; and finds a basis for a positive decision in favor of bi-metallism.

JOHN STUART MILL. A Criticism, with Personal Recollections. By ALEXANDER BAIN, LL. D. Henry Holt & Co. Pp. 201. Price, $1.25.

THIS volume is precisely what was needed to supplement Mill's "Autobiography." While, on the one hand, that work is invaluable as a disclosure of personality, and as an interpreter of mental experience, such as none but the author himself could give, on the other hand it is full of the necessary bias and the limitations of an autorepresentation, and contains defects and omissions which only another mind could supply. Dr. Bain was pre-eminently the man to add this counterpart to Mill's own sketch of his life. He knew the man intimately, was himself an independent student of the whole range of questions to which Mill devoted himself, while the two men were in such sympathy that Mr. Mill intrusted to Professor Bain the revision of the proof-sheets of the "Logic," his greatest and most important work. With such a preparation, Professor Bain could not fail to give us a most interesting sketch, and which is at the same time a critical estimate of Mill's publications. Much light is thrown on the circumstances of the production of each work—how the author was led to the subject, how his views were modified or expanded, and how he was influenced by the leading contemporary minds of his time. There is an interesting analysis of Mill's relation to Comte, and a still more inter-

esting statement of his relations with Mrs. John Taylor, whom, after twenty years' acquaintance as a married woman, after the death of her husband, Mill married. There is a critical examination of his extravagant claims in regard to the talent of this lady, and also of Mill's attitude toward the "woman question" generally.

There are various important points, on which Dr. Bain disagrees with Mill, which we should like to have seen further elucidated, and to a consideration of some of these we may return in future. But the points of objection are generally well taken. We are gratified to observe that Dr. Bain holds exactly the opinion which we have maintained in regard to Mill's celebrated "University Address" on education. As the questions involved are of permanent interest, it may be well to quote what Bain says about this performance of Mill:

The St. Andrews address was a very lengthened performance; its delivery lasted three hours. It aimed at a complete survey of the higher education. Its absolute value is considerable; but, in relation to the time, place, and circumstances, I consider it to have been a mistake. Mill had taken it into his head that the Greek and Roman classics had been too hardly pressed by the votaries of science, and were in some danger of being excluded from the higher teaching; and he occupies nearly half of the address in vindicating their importance. The second half is a vigorous enforcement of the claims of science.

The performance was a failure, in my opinion, for this simple reason, that he had no conception of the limits of a university curriculum. The Scotch universities have been distinguished for the amount of study comprised in their arts degree. Mill would have them keep up the classics intact, and even raise their standard; he would also include a complete course of the primary sciences—mathematics, physics, chemistry, physiology, logic, and psychology—to which he would add political economy, jurisprudence, and international law. Now at present the obligatory sciences are mathematics, natural philosophy, logic, and moral philosophy. If he had consulted me on this occasion, I should have endeavored to impress upon him the limits of our possible curriculum, and should have asked him to arbitrate between the claims of literature and science, so as to make the very most of our time and means. He would then have had to balance Latin and Greek against chemistry, physiology, and jurisprudence; for it is quite certain that both these languages would have to be dropped absolutely, to admit his extended science course. In that case he would have been more careful in his statements as to the Greek and Latin languages. He would not have put these languages as synonymous with "literature"; and he would have made much more allowance for translations and expositions through the modern languages. He would have found that at the present day we have other methods of correcting the tendency to mistake words for things than learning any two or three additional languages. He would not have assumed that our pupils are made all "to think in Greek"; nor would he have considered it impossible to get at the sources of Greek and Roman history without studying the languages. If he had a real opponent, he would not have given the authority of his name to the assertion that grammar is "elementary logic." His mode of speaking of the style of the ancient writers, to my mind at least, is greatly exaggerated. "Look at an oration of Demosthenes; there is nothing in it which calls attention to itself as style at all . . . . The Athenians do not cry out, What a splendid speaker, but, Let us march against Philip." He also gives way to the common remark that the teaching of Latin and Greek could be so much improved as to make it an inconsiderable draft upon a pupil's energies. On this point he had no experience to go upon but his own, and that did not support his position.

In the scientific departments he carries out strictly the Comte hierarchy of the fundamental sciences, and, in this respect, the address was valuable as against the mischievous practice of culling out a science from the middle of the series, say chemistry, and prescribing it by itself to the exclusion of its forerunners in the hierarchy. While he speaks fairly and well on the mathematical and physical sciences, his remarks on the moral and political display, as usual, the master's hand. He next goes on to talk of free thought, on which he maintains a somewhat impracticable ideal for our universities. From science he proceeds to art, and enforces a favorite theme—the subservience of poetry to virtue and morality. One feels that on this topic a little more discrimination was necessary; art being a very wide word. His conclusion was a *double entendre:* "I do not attempt to instigate you by the prospect of direct rewards, either earthly or heavenly; the less we think about being rewarded in either way, the better for us."

In the reception given to the address, he was most struck with the vociferous applause of the divinity students at the free-thought passage. He was privately thanked by others among the hearers for this part.

THE MEDICAL ADVISER IN LIFE ASSURANCE. By EDWARD HENRY SIEVEKING, M. D. Philadelphia: P. Blakiston, Son & Co. Pp. 206. Price, $2.

THE author's object is to furnish the reader with information which, if it is to be found at all in the ordinary works of medicine, is so scattered as not to be readily

available. Much of the substance of the book is derived from the experience of the author, or has been placed at his disposal by friends who have been engaged in the study of questions connected with life insurance. The special topics of "The Normal Man," "The Duties of the Medical Officer," "Hereditary Influences," "The History of the Individual," "The Insuree's Liability to Disease," and "The Medico-Legal Aspects of Life Insurance," are considered.

GEOLOGICAL SURVEY OF NEW JERSEY. Annual Report of the State Geologist for the Year 1881. Trenton, New Jersey: John L. Murphy. Pp. 308, with Map and Table of Temperatures.

THE topographical survey has been pushed, during the year, westward across Morris County and the central part of Warren County, to the Delaware River at Belvidere, the work covering an area of 360 square miles, and making, with what had been previously done, a total area of about 1,260 square miles completed. In the several chapters of the report are considered the encroachments of the sea upon the low-lying lands of the shore, the ores of iron and other metals, and quarries of stone in the State, with statistics; and more than half of the volume is occupied with the consideration of "the climate of New Jersey." An excellent geological map of the State accompanies the report.

FROM RIVER TO SEA. A Tourists' and Miners' Guide from the Missouri River to the Pacific Ocean, *via* Kansas, Colorado, New Mexico, Arizona, and California. CHARLES S. GLEED, Editor. Chicago: Rand, McNally & Co. Pp. 240. Price, $1.

THIS work is designed to supply a want. Its purpose is to give people a good general idea of the vast territory which is tributary to the new line of railway communication (Atchison, Topeka and Santa Fé Railway) between the Missouri River and the Pacific Ocean. It embodies a great deal of information of a kind which the traveler looks for, and will be generally useful to him. The illustrations, which are fairly well but not finely executed, lose a large part of their value by being inserted without reference to the text, and in a not regular order.

POLITICAL INSTITUTIONS: BEING PART V OF THE PRINCIPLES OF SOCIOLOGY. The Concluding Portion of Volume II. By HERBERT SPENCER. Pp. 457. Price, $1.50.

THE second volume of Spencer's "Principles of Sociology" is devoted to the evolution of I, Ceremonial Institutions, and II, Political Institutions; and, as the first part was issued separately about two years ago, the second part is now also issued separately, for the convenience of those who have procured the other.

Although this work is in its nature historical, yet it is necessary to discriminate between the method of ordinary history and that here adopted. Common history only applies to the later stages of progress, and it would deal with political institutions only in their higher modifications. But the idea of "development" implies that of origin, and carries us back to prehistoric times and primitive conditions. The question is, in what way the earlier or rudimentary forms of political institutions grew up. This problem lies back of that of the ordinary historian, is of a deeper nature, and can only be successfully pursued under the guidance of some general theory of social genesis which will throw a common light on the development of ceremonial, political, ecclesiastical, and industrial institutions. Such a theory is that of evolution, and accordingly it is here made a part of the exposition of that theory. Of the difficulties of the exposition growing out of the nature of the subject, and the imperfections due to its subordination to a larger scheme of thought, the author says:

> The division of the "Principles of Sociology" herewith issued, deals with phenomena of Evolution which are, above all others, obscure and entangled. To discover what truths may be affirmed of political organizations at large is a task beset by difficulties that are at once many and great—difficulties arising from unlikeness of the various human races, from differences among the modes of life entailed by circumstances on the societies formed of them, from the numerous contrasts of sizes and degrees of culture exhibited by such societies, from their perpetual interferences with one another's processes of evolution by means of wars, and from accompanying breakings-up and aggregations in ever-changing ways.
>
> Satisfactory achievement of this task would require the labors of a life. Having been able to devote to it but two years, I feel that the re-

sults set forth in this volume must of necessity be full of imperfections. If it be asked why, being thus conscious that far more time and wider investigation are requisite for the proper treatment of a subject so immense and involved, I have undertaken it, my reply is that I have been obliged to deal with political evolution as a part of the general Theory of Evolution; and, with due regard to the claims of other parts, could not make a more prolonged preparation. Any one who undertakes to trace the general laws of transformation which hold throughout all orders of phenomena must have but an incomplete knowledge of each order; since, to acquaint himself exhaustively with any one order, demanding, as it would, exclusive devotion of his days to it, would negative like devotion to any of the others, and much more would negative generalization of the whole. Either generalization of the whole ought never to be attempted, or, if it is attempted, it must be by one who gives to each part such time only as is requisite to master the cardinal truths it presents. Believing that generalization of the whole is supremely important, and that no one part can be fully understood without it, I have ventured to treat of Political Institutions after the manner implied: utilizing, for the purpose, the materials which, in the space of fourteen years, have been gathered together in the "Descriptive Sociology," and joining with them such further materials as, during the last two years, have been accumulated by inquiries in other directions, made personally and by proxy.

STATISTICS OF THE PRODUCTION OF THE PRECIOUS METALS IN THE UNITED STATES. By CLARENCE KING, Special Agent of the Census. Washington: Government Printing-Office. Pp. 94, with Six Plates.

THE information on which this report is based has been procured, so far as is possible, directly from the producers of bullion. It was not expected that completeness could be reached in this way, for many small producers would be overlooked or would fail to report, but the plan gives a nearer approach to accuracy than can be gained from the comparison of the receipts of domestic bullion at the mints and assay-offices, or from an examination of the bullion accounts of the express companies—the only other sources of information that were open. A comparison of the annual output of different States shows that the United States produces 33·13 per cent of the gold yield of the whole world, 50·59 per cent of the silver, and 40·91 per cent of the total. Of the aggregate supply of the precious metals, North America furnishes 55·78 per cent.

HAND-BOOK OF INVERTEBRATE ZOÖLOGY FOR LABORATORIES AND SEASIDE WORK. By W. H. BROOKS, Ph. D. Boston: S. E. Cassino. Pp. 392, 200 Cuts. Price, $3.

THIS volume has very strong claims upon the biological student; but for the beginner, especially if he lives near the sea, it is incomparable. The art of starting a beginner aright in any branch has not yet been perfected, but Dr. Brooks has made a successful stroke in this direction for zoölogical science. The work has been planned with reference to the exigencies of systematic study, and to put the student upon the right track to attain the mastery of the subject with the least waste of exertion. Nothing is introduced that is not wanted. Generalizations and comparisons are omitted, on the principle that the beginner shall first get at the facts, in order that he may subsequently grasp and make the generalizations his own. The work is therefore not a text-book, but a hand-book of practical study, and is admirably adapted for self-instruction. In his prefatory remarks describing the work, the author says: "Most lecturers upon natural science find, no doubt, that preliminary work, the presentation of facts upon which science is based, absorbs so much time that there is no room for a philosophical discussion of the scientific aspects of the subject. I have therefore attempted to show the student how to acquire a knowledge of the facts for himself, in order to remove this burden from lecturers and text-books."

The types selected for description are, of course, but few compared with those considered in systematic works; but still they cover wide zoölogical ground, and are sufficient to prepare for more comprehensive research. In the treatment of each type the author has not attempted to present all that is known about it, but simply to guide the beginner to those features which he can find and observe for himself. And so also with the illustrations. The minute details of complicated structural figures are omitted, and only those given that it is necessary for the beginner himself to discover in his examination of the specimens. For this purpose, the illustrations are greatly superior to any we have elsewhere seen.

The book begins with the examination

of amœbæ, and the opening directions for obtaining them will give a good idea of the clearness, directness, and simplicity with which the whole work is written:

Amœbæ are frequently to be found in abundance in the superficial ooze which forms a thin layer upon the bottom of nearly every quiet body of fresh water. The ooze may be collected from a pond, stream, or ditch, by gently and slowly skimming the bottom with a tin dipper fastened to a long handle. In gathering the ooze be careful to barely skim the surface, and to avoid disturbing the black mud which usually occurs just below the ooze.

Transfer the material thus gathered to a collecting-bottle, and gather ooze from several bodies of water, preserving each specimen in a separate bottle, for amœbæ may be abundant in one locality and almost absent in another. Pour the ooze into shallow dishes, such as soup-plates or baking-dishes, putting enough into each dish to form a layer about an eighth of an inch deep over the bottom.

Place the dishes near the window, where they will be well lighted without exposure to the direct rays of the sun; fill them with fresh water, and allow them to stand undisturbed for two or three days, in order to allow the amœbæ to creep out of the ooze and accumulate at its surface.

If a permanent supply of amœbæ is desired, each dish may be converted into a small aquarium by the addition of a few floating water-plants, such as "duck-weed," and when covered with a pane of glass, to exclude dust and prevent excessive evaporation, may be kept in good order for several months by simply replacing with fresh water the loss by evaporation.

In a day or two a thin brownish-yellow film will usually be visible over the whole or parts of the surface of the ooze; and portions of this film, almost entirely made up of microscopic organisms which have crept to the surface, may now be examined for amœbæ, in the following manner.

It only remains to add that this work is published at a very low price. Considering its cost and elegance, we hardly know of another so cheap a book. And, considering that there is no other book at all like it to serve the purposes of introductory study in its field, it ought to be in wide demand by the students of natural history.

ESSAYS ON THE FLOATING MATTER OF THE AIR, IN RELATION TO PUTREFACTION AND INFECTION. With Illustrations. By JOHN TYNDALL, F. R. S., M. D. D. Appleton & Co. Pp. 338. Price, $1.50.

SOME of the researches contained in this book have appeared in the pages of "The Popular Science Monthly," and nothing, therefore, need be said to our readers that is merely commendatory of their interest. The volume is the result of extended researches into one of the obscurest of subjects—the nature, conditions, and influence of the invisible microscopic life of the atmosphere. Any inquiry into the dust and floating contents of the air, if thoroughly pursued, leads to the more subtile question of infinitesimal forms of life and their germs as floating elements of the breathing medium. Profound problems are here encountered: Are these germs spontaneously originated, or are they subject to the laws of propagation which govern all other grades of life? Again, are these germs the seeds of disease which affect the higher forms of life, and thus become of the highest moment to the physician and the hygienist? The import of the subject has been disclosed only within the last few years, and depends upon the perfection of the microscope, and the most refined researches into the nature and effects of fermentation and putrefaction. Many able men in different countries have been working, with intense assiduity, over different branches of this momentous inquiry; but it was on many accounts fortunate that Professor Tyndall, about a dozen years ago, saw its importance, and brought all his resources to bear upon its systematic investigation. That he has thrown much more light upon the subject by his skillful and extensive experiments, and that he has made very important contributions to the establishment of the germ theory of disease, will not be questioned. But in still another respect it is fortunate that he identified himself with its elucidation. By his rare power of exposition, and his wonderful clearness of statement, he has done more, perhaps, than all other writers to impress the medical profession and the public both with the vital importance of the subject and the advance that has been made in the establishment of its fundamental principles. His present book embodies the main results of his original work, and, what is more, it presents them in so lucid and inviting a form that all classes of readers will be equally pleased and instructed by his views.

There is, perhaps, in the whole field of science no illustration more striking than is here afforded of the fruitful practical

application of investigations undertaken for the simple purpose of the extension of knowledge, with no perception of its ultimate utilities. While one division of laborers, spurred by the urgent necessities of observers, spent their energies in bringing the microscope up to its highest power, another division was equally absorbed in finding out what could be known of the newly revealed world of microscopic life. The stimulus of the love of discovery was sufficient to insure the successful progress of both. But now we begin to see the beneficent ripening of their results as they could not see it. As a legitimate issue of those labors, we have arrived at views of the nature and propagation of diseases that will make an epoch in the advance of medical and hygienic science. We print, in the present Monthly, the Introductory Note to Professor Tyndall's volume, which is very instructive in regard to the present position and future influence of the "Germ Theory of Disease."

A DICTIONARY OF MUSIC AND MUSICIANS (A. D. 1450–1881). By Eminent Writers, English and Foreign. Edited by GEORGE GROVE, D. C. L. Part XIV. London and New York: Macmillan & Co. Pp. 128. Price, $1.

THE present number includes the titles from Richter to Schorberlechner. The plan and execution of the work are commendable. The information is given in well-written and easily readable articles, the length of which is adapted to the character and importance of the subject. Biographies of eminent composers, performers, instrument-makers, and other musical persons, predominate in the present number, ranging from few-line notices of little distinguished instrumentalists to the sixteen-page article that is given to a distinguished composer like Rossini. Besides these, the number before us has paragraphs, within a few pages, on such subjects as "Ridotto," the opera of Rienzi, "Rigadoon," with a musical passage to show what it is, the opera of Rinaldo, "Rinforzando," "Ripieno," "Ritardando" and its synonyms, "Ritornello" with other musical illustrations, etc. We mention these heads to give only an inadequate idea of the abundance and variety of the material with which the work deals.

OUR HOMES. By HENRY HARTSHORNE, A. M., M. D. Philadelphia: P. Blakiston, Son & Co. Pp. 150. Price, 50 cents.

A VOLUME in the series of "American Health Primers," edited by Dr. W. W. Keen. It is a practical, pleasant-reading treatise on house-building, house management, and house sanitation, considering the subject under the heads of situation, construction, light, warmth, ventilation, water-supply, drainage, disinfection, population (the relations of density of population to health), and working-men's homes.

THE WINE QUESTION IN THE LIGHT OF THE NEW DISPENSATION. By JOHN ELLIS, M. D. New York: Published by the author. Pp. 228.

THE controversy respecting the use of fermented or unfermented wine in the communion service is considered here in the light of the teaching of the Swedenborgian Church, with citations from authorities and opinions outside of that church, all going to sustain the presumption that unfermented wine is the kind to be used.

THE RHYMESTER; OR, THE RULES OF RHYME. A Guide to English Versification. By the late TOM HOOD. Edited, with Additions, by ARTHUR PENN. New York: D. Appleton & Co. Pp. 208. Price, $1.

THE author believes that verse-making —not trying to write poetry—is of use as an exercise for fixing accurate pronunciation; and that, if done at all, it should be well done. He accordingly gives here the rules for doing it well. Many changes have been made by the American editor, of which the more material ones are marked, and chapters have been added on the sonnet, the rondeau, and the ballade, and on the other fixed forms of verse.

THE BOOKS OF ALL TIME. A Guide for the Purchase of Books. Compiled by F. LEYPOLDT and LYNDS E. JONES. New York: F. Leypoldt. Pp. 80.

A LIST of approved books is given, with the prices of the best or most popular editions; and to each title are attached bits of criticism which throw some light on the characteristics of the author. The list, as a whole, is a good one and deserves approval, but would have been better for a little closer pruning away of mediocre books.

A READING DIARY OF MODERN FICTION. Containing a Representative List of the Novels of the Nineteenth Century, preceded by Suggestive Remarks on Novels and Novel-reading. New York: F. Leypoldt. Pp. 150.

THE main object of this work is stated to be "to present a survey of all that is considered worth reading in the domain of modern fiction, and thus to make easy a daily record of what has been read and what to read next, with a view to comparing notes and a mutual exchange of recommendations among congenial friends." For this purpose a column in each page is given of "Books worth Reading," and is followed by blank columns for estimating merit, and recording other books that may be suggested. Our remark is, that the catalogue is too full. We should not like any one for whose mental cultivation we cared to become acquainted with so many novels. If the list were only one tenth as large, it would be many times more valuable.

THE PRACTICE OF COMMERCIAL ORGANIC ANALYSIS. By ALFRED H. ALLEN, F. I. C., F. C. S., Lecturer on Chemistry and Public Analyst. Volume II, Hydro-carbons, Fixed Oils and Fats, Sugars, Starch, Alkaloids, and Organic Bases, etc. Philadelphia: Presley Blakiston. 1882. 8vo. Pp. 561. Price, $5.

To those chemists who are already the fortunate possessors of the first volume of Mr. Allen's work, it will be good news to know that the second volume has at last been issued, for its appearance has been awaited with some impatience. In the former volume we had a full description of the alcohols, with the acids and ethers derived from them; also the phenols, carbolic, salicylic, and benzoic acids, as well as all the cyanogen bodies. The present volume, which is much larger than the former, contains the new methods of analysis of many articles of present interest. The analytical chemist will probably turn first to the chapter on glucose and grape-sugar, for on these subjects reliable and practicable information is meager. Here, for the first time, we believe, methods for estimating maltose are given, and attention is called to the error which it causes when Fehling's solution is employed for the estimation of dextrose in commercial glucose. The method of determining dextrose, maltose, and dextrine in the same solution from the rotatory and reducing power, in connection with the specific gravity of the solution, is clearly and concisely given.

Next in interest to glucose is the analysis of butter, and, although the chemist has not yet attained perfection in this, we find here the best methods known at present for detecting oleomargarine. The last chapter, a lengthy one, is devoted to aniline derivatives, the assay of aniline dyes, the identification of coal-tar colors, and the recognition of dyes on tissues.

We bespeak for the book the most favorable attention, because it is the *only* complete work on this subject in the English language, because it is new and up to the times, and because its author is well known as a practical analyst. The work is indispensable to the laboratory.

CURRENCY; OR, THE FUNDAMENTAL PRINCIPLES OF MONETARY SCIENCE POSTULATED, EXPLAINED, AND APPLIED. By HUGH BOWLBY WILLSON. New York: G. P. Putnam's Sons. Pp. 309. Price, $1.50.

THE author contemplated, when he began, many years ago, his investigations on the subject of this work, writing a synopsis of the theories and practices of ancient and modern nations in respect to their currencies, but soon discovered that he would not have time to perform the task. The present work, the scope of which is more limited, has grown out of a series of postulates which he published in 1875–'76, in a London journal, for the purpose of directing attention to the desirability of embodying the ascertained and generally accepted principles of monetary science in a few "simple if not self-evident" propositions. Professor Bonamy Price, of Oxford, wrote him a note of thanks for his letter, saying, "It is exceedingly good, and I rejoice over it much, especially the postulates and principles." Much space is devoted to attacking the "prejudices and ignorance" which uphold the present systems of issuing and supplying paper money, they containing much that is regarded as at variance with scientific principles. The plan of delegating the issue of paper money to banking corporations other than the government is assailed; and

the result of the author's deductions "has been the evolvement of a purely automatic method of supplying both coined and paper money," with supply and demand as the only motive power to be used in keeping the automaton in motion. In opposition to the "mercantile theory," which seeks to accumulate the largest stores of the precious metals in a country, a plan is contended for which leaves those metals "free to the distribution of the natural forces of industry and trade."

HISTORY OF THE WATER-SUPPLY OF THE WORLD. Arranged in a Comprehensive Form from Eminent Authorities. By THOMAS J. BELL, Assistant Superintendent of the Cincinnati Water-Works. Cincinnati: Peter G. Thomson. Pp. 134. Price (paper), 50 cents.

THE original intention of this work was to arrange a compilation of general and local information on the subject of water-supply in all of its bearings, with special reference to Cincinnati, and to the project for a new supply for that city. As the work progressed, its scope became broader, and the plan assumed a more comprehensive form. The work contains a description of the various methods of water-supply, and discusses the pollution and purification of water, sanitary effects, and analyses of potable waters; and, further, considers other topics having special reference to Cincinnati, the Ohio River, and the proposed water-supply of the city.

A COMPENDIOUS DICTIONARY OF THE FRENCH LANGUAGE. Adapted from the Dictionaries of Professor Alfred Edwall. By GUSTAVE MASSON. New York: Macmillan & Co. Pp. 416. Price, $1.

A MOST excellent dictionary for daily use. The compiler has endeavored especially to realize the qualities of accuracy and completeness, and to keep equally distant from exaggerated concision and overabundance of detail. The letter-press is clear, yet compact. The matter is arranged in four columns to the page, the words are printed in bold-face type to catch the eye readily, and the definitions are satisfactorily full. Particular attention has been paid to etymologies in the French-English part. A supplement, giving the principal diverging derivatives or doublets in the language (showing how words have varied from the Latin roots and from the congeners in other Romance languages) is of much use and interest to students. The Chronological Tables of the History of French Literature from the earliest period to the present day, of chronicles and memoirs, and the other literary information with which the work is introduced, will be welcome to many who would otherwise find it difficult to obtain, from the numerous sources from which it would have to be drawn, the information which they convey.

HOW THE GREAT PREVAILING WINDS AND OCEAN-CURRENTS ARE PRODUCED, AND HOW THEY AFFECT THE TEMPERATURE AND DIMENSITY OF LANDS AND SEAS. By C. A. M. TABER. Boston: A. Williams & Co. Pp. 82. Price, 40 cents.

THE author states as a reason for this publication that, after many years of experience on the oceans, he has found that the generally accepted theories of the causes of the great winds and currents were not in harmony with the world-wide operations of nature, but were rather adapted to certain areas of oceans and continents than applicable to larger portions of the globe, "where the great movements of the atmosphere and ocean are not concordant with the generally accepted explanations." He reviews the theories of Hadley, Maury, Adhemar, Croll, Geikie, and other authors who have written upon the subject, shows wherein he regards them as deficient, and elaborates his own theory, in which a depression of sea-level on the western, and elevation on the eastern sides of the ocean, by the force of the west winds, and an independent circulation of waters around the poles, form important parts.

PRIMARY HELPS: BEING NO. 1 OF A NEW SERIES OF KINDERGARTEN MANUALS. By W. N. HAILMANN, A. M., editor of "The Kindergarten Messenger and the New Education." Syracuse, New York: C. W. Bardeen. Pp. 29, with Fifteen Plates. Price, 75 cents.

PROFESSOR HAILMANN is an enthusiastic Kindergartner, a practical teacher, and a member of the Board of Education of Detroit, Michigan. It has been his aim for years to bring those engaged in the Kindergarten work into harmony, and especially to

establish a connection between the Kindergarten and the public schools. The present book is the first fruits of his efforts in this direction, and aims to make the principles of Froebel applicable to primary schools.

REPORT ON THE GEOLOGY OF THE HENRY MOUNTAINS. By G. K. GILBERT. Washington: Government Printing-Office. Pp. 170, with full-page Engravings and Photographs.

THE author expresses a considerable degree of satisfaction at the manner in which his work in the survey of these mountains has been accomplished. He had his own way in conducting it, and pursued it under circumstances of exceptional advantage, with the result that, he says, "so thorough was the display [of the formations], and so satisfactory the examination, that, in preparing my report, I have felt less than ever before the desire to revisit the field and prove my conclusions by more extended observation." The Henry Mountains are not a range, and have no trend, but are simply a group of five individual mountains, separated by low passes, and without discernible system of arrangement, situated in Southern Utah, on the right bank of the Colorado River of the West, and between its tributaries, the Fremont and the Escalente. The highest peaks rise about 5,000 feet above the plateau at their base, and 11,000 feet above the level of the ocean. At the time of their discovery by Professor Powell they were in the center of the largest unexplored district in the United States; and they are in a desert country that has hardly any economic value.

A BIBLIOGRAPHY OF FOSSIL INSECTS. By SAMUEL H. SCUDDER. Pp. 48.

THIS work forms one of the series of the "Catalogue of the Library of Harvard University," and is one of the first formal attempts to collect separately the titles of papers on fossil insects. It shows the results of great labor, for it gives not only the titles of books and papers on the subject, but also a very large number of references to works and essays in which fossil insects are only referred to, or form one among other topics of equal prominence, which are touched upon in the course of a chapter, essay, or book, and in all the principal languages of science. Except when otherwise stated, all the papers quoted have been examined by the author personally.

TABLES FOR THE DETERMINATION, DESCRIPTION, AND CLASSIFICATION OF MINERALS. By JAMES C. FOYE, Ph. D., Professor in Lawrence University. Chicago: Jansen, McClurg & Co. Pp. 85. Price, $1.

THE object of this work is to furnish tables by means of which students may, with as few easy tests as possible, learn to determine and classify minerals found in the United States, and become familiar with their principal characteristics. Two tables serve for the determination of species; a third gives the crystalline structure and other distinctive characteristics of each species; a fourth classifies the species according to "Dana's Mineralogy"; and a fifth classifies by basic elements and ores. The appendix gives the distinctions between some of the closely allied species and varieties. A great deal of information is compressed into a small space.

PUBLICATIONS RECEIVED.

The Little Mountains East of the Catskills. By W. M. Davis. Pp. 33. With Plate.

Scientific Proceedings of the Ohio Mechanics' Institute. Vol. I. No. 2. Cincinnati, May, 1882. Pp. 50.

Clinical Contributions to Electrical Therapeutics. By Romaine J. Curtiss, M. D. Joliet, Illinois. Pp. 52.

Quarterly Report of the Bureau of Statistics for Three Months ended March 31, 1882. Washington: Government Printing-Office. Pp. 96.

Note on the Aurora of April 16-17, 1882. By H. Carvill Lewis. Pp. 9. Illustrated.

Proceedings of the National Association for the Protection of the Insane and the Prevention of Insanity. New York: G. P. Putnam's Sons. 1882. Pp. 55.

Missouri Historical Society. Publication No. 6. Archæology of Missouri. By F. H. Hilder. St. Louis, Missouri. Pp. 17.

A New Theory of the Suspension System, with Stiffening Truss. By A. Jay DuBois, Ph. D. Pp. 43.

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POPULAR MISCELLANY.

The Great Telescope at Princeton.—The new telescope for the Halsted Observatory at Princeton has been mounted within the past few weeks, and is now ready for work. In magnitude it ranks at present as fourth among the great refracting telescopes of the world, and second in the United States. Its only superiors in size are the Vienna refractor, of twenty-seven inches diameter, the telescope of the Naval Observatory at Washington, twenty-six inches in diameter, and the telescope of Mr. Newhall, at Newcastle, in England, which has an aperture of twenty-five inches. A number of still larger instruments are indeed under construction, but it will be some time before any of them are actually in place. The object-glass of the Princeton telescope is twenty-three inches in diameter, and has a focal length of thirty feet. The glass disks were cast by Feil, in Paris, but the telescope was made by Alvan Clark & Sons, of Cambridge. Though the telescope is a little smaller than the Washington equatorial, its mounting is considerably heavier and firmer, and is improved in many respects. The regulator of the driving-clock is unusually powerful, and, to prevent friction and wear of its pivots, its shaft is floated in mercury. The clamps and slow-motions are all managed without removing the eye from the eye-piece, and the declination circle is also read from the eye-end by a new and ingenious arrangement of the makers. The object-glass is peculiar in having its two lenses separated by a space of about seven inches, so as to allow a free circulation of air between them, thus greatly diminishing the disturbing effect of changes of temperature. This construction secures also freedom from the "ghosts" (formed by reflection between the lenses) which are so troublesome in many large instruments. The curves of the lenses are not those usually employed, but are somewhat like those of the Gaussian system, though not so deep. The color and spherical aberration are very perfectly corrected, and the performance of the glass, so far as can be judged from a few nights' work, is extremely fine. The instrument is, of course, provided with all the usual micrometers, eye-pieces, and other accessories, but as its chief occupation, for the present at least, is to be in the line of stellar spectroscopy, special attention has been given to the spectroscope, which is the most powerful ever made for star-work. It is a direct-vision instrument, on the plan of that used for some years back at Greenwich, though much larger. It was constructed by Hilger, of London, under the kind supervision of Mr. Christie (the present Astronomer Royal), in accordance with his own designs. It has

three of his so-called half-prisms, of such size as to take a beam two and one quarter inches in diameter, and is nearly six feet long. The whole cost of the telescope and spectroscope was $26,000, which was provided by the generosity of Robert Bonner, R. L. Stuart, and other friends of science and the college. The observatory itself, of which the corner-stone was laid sixteen years ago, has been newly fitted up for its occupant. A gas-engine furnishes the power for moving the dome and working the shutters, and it also drives an Edison dynamo electric machine which provides a powerful current to be used for lighting purposes, or to supply the spectra of gases and metals to be compared with the spectra of the stars.

American Archæological Researches.—The third annual report of the Archæological Institute of America reviews the work that has been pursued by the agents of the institute in archæological explorations in New Mexico and Mexico, and in the excavations at the ancient Greek city of Assos, and includes the first report of the committee on the American school of classical studies at Athens. Mr. Bandelier, who had been exploring in New Mexico in the service of the institute, spent some time in Mexico, first at Cholula, where he studied the history of the city and the manners and customs, the habits and superstitions, and the domestic architecture of the present native Indian inhabitants. He inquired into the origin and character of the ancient Mexican deity Quetzal-Chohuatl, and the significance of the myth attached to his name, and made a study of the great pyramid of Cholula. The latter, he declares, is not entitled to be called a pyramid, but is only a huge mound, some two hundred feet high, which originally covered an area of about sixty acres, and now presents the appearance of three distinct terraces, surrounding and supporting a conical hill, very wide, and much overgrown with shrubbery. It is constructed of materials precisely similar to those which make up the plain on which it stands, and appears not to have been all erected at one time, but to be the accumulation of successive periods of labor. Mr. Bandelier believes that the structure was designed to hold immense communal buildings, like those at Pecos, in New Mexico, but in size approaching the great edifices at Palenque and Uxmal, and all built around a vast court, in the center of which stood an enormous "worship-mound," and that it was built by the Toltecs, or Mayas. Mr. Bandelier also visited Mitla, where he secured accurate plans and measurements of the most important buildings, thirty-nine in number. The so-called palaces are not greatly different from the pueblos of New Mexico, and are described as built and ornamented without any knowledge of mechanical contrivances, dark and imperfectly ventilated, and only a "barbaric effort of a barbarous people." His conclusion, drawn from the shape and size of the single apartments, is that they were not intended for every-day abodes, but only as shelters at night and in bad weather, and retreats for the women and children during a hostile attack—communal structures, differing from the similar constructions of other Indian tribes "only in so far as the exigencies of a different climate or of varying resources demanded." M. Louis H. Aymé, United States consul at Merida, has entered into a contract to explore, as agent of the institute, such places in Yucatan as have not recently been examined by Dr. Le Plongeon or M. Charnay. The ruins of Yucatan have suffered great destruction during the forty years since they were visited by Stephens.

The American Association.—The thirty-first annual meeting of the American Association for the Advancement of Science will be held at Montreal, beginning August 23d, under the presidency of Principal J. W. Dawson, LL. D., F. R. S., of McGill University. The headquarters of the association will be at McGill University, where members will register as soon as possible after their arrival. The hotel headquarters will be at the Windsor Hotel. The offices of the local committee and of the permanent secretary will be at the university. The general sessions and the meetings of the sections and committees will all be held in the university buildings. The permanent secretary, Professor F. W. Putnam, may be addressed at Salem, Massachusetts, till August 17th, after which his address will be at the Windsor Hotel, Montreal, Canada.

The British Association.—The fifty-second meeting of the British Association will be held at Southampton, beginning August 23d, when the chair will be resigned by Sir John Lubbock and assumed by Dr. C. W. Siemens, F. R. S., president-elect, with the usual address appropriate to the occasion. The addresses at the evening general meetings will be, "On the Tides," by Sir William Thomson, F. R. S., August 25th, and on "Pelagic Life," by Professor H. N. Moseley, August 28th. The presidents of the sections will be: A, *Mathematical and Physical Science*, Lord Rayleigh; B, *Chemical Science*, Professor D. Liveing; C, *Geology*, R. Etheridge, F. R. S.; D, *Biology*, Professor A. Gamgee, with Professors Gamgee, M. A. Lawson, and W. Boyd Dawkins as presidents in the Departments of Anatomy and Physiology, Zoölogy and Botany, and Anthropology; E, *Geography*, Sir R. Temple, Bart.; F, *Economical Science and Statistics*, the Right Hon. G. Sclater-Booth; and G, *Mechanical Science*, John Fowler, F. G. S. Excursions to places of interest in the neighborhood of Southampton will be made on the afternoon of Saturday, August 26th, and on Thursday, August 31st.

Forests and Climate.—Dr. J. M. Anders, in the "American Naturalist," has carefully examined the influence of forests upon climate and rain-fall. The principal influence exerted by woods upon climate is as wind-breaks, in which capacity the service they render is familiar enough. The experiment has been tried extensively in France of planting trees in belts one hundred metres apart, with marked benefit to the climate. Forests may slightly promote the condensation of moisture by inducing an upward movement of the air, as mountains are known to do on an extensive scale; but their action in this respect, on account of their low height, is not important enough to be made account of. Woods play a more important part in furnishing the air with moisture by transpiration of water through their leaves. It is computed from experimental tests that they give off in this way twelve times as much water as is evaporated directly from the soil on which they stand, twice as much as goes up from a free soil, and more than is emitted from an equal body of water. They are able to do this, and keep it up, because they are at all times supplied with an abundant store of moisture for transpiration. This is given them partly by the power which their roots have to attract moisture from every direction; partly by the retention of the rain-fall in their net-work; and partly by the property possessed by vegetable mold of absorbing moisture and holding it. This power of evaporation is shared by the humbler vegetation, and it operates nearly constantly, even during long droughts. Climate is also materially affected by this quality, for moist air during winter tends to moderate extreme cold and during summer produces a refreshing coolness. Now, since it is established that forests moisten the air over, in, and to some extent around themselves, "may we not be pardoned for concluding that warm currents sweeping over a country and striking the cool moist air in and above the forests, and mingling with it, would have a portion, at least, of the contained moisture condensed into gentle showers, extending their beneficent influence to neighboring fields? Again, let some stray current come along, of a lower temperature than the air of the forest, and the moist air of the forest would readily be condensed, since it is a well-known fact that a moist air discharges its vapor more readily in the form of rain than a drier atmosphere. We have now seen how trees can cause local rains; it will also be observed that the rain is formed chiefly above the forest, though it may be through the influence of winds that it falls to the earth for some distance around. By increasing the frequency of light rains, forests tend to obviate drought, which is of ultimate importance to the farmer's crops and vegetation in general. It will be seen that all our deductions have been drawn largely from the known facts from observations." Forests also produce abundant dews, an office not to be despised, for heavy dews are often very refreshing to vegetation.

Atmospheric Pressure and the Sea-Level.—One of the most interesting phenomena of the recent winter in Europe was a remarkable depression of the level of the Mediterranean Sea under the influence of the high barometric pressures of December

and January. At Antibes, in particular, the water-level sunk considerably, falling about a foot during the first fortnight in January, and laying bare bottoms over which small boats had previously sailed with ease. A similar depression was noticed on the coasts of Italy, particularly at Fiumicino. A French *savant*, M. Daussy, has estimated the amount of this influence, and calculated that it is equal to the product of the excess of height over the normal by the density of mercury. The action of atmospheric pressure is so manifest at other points in the Mediterranean, according to Dr. Niepce, of Nice, that it almost alone constitutes the tidal force. The fact is confirmed in a paper on the climate of Venice, which has recently been published by M. Tono, of the Meteorological Observatory in that city, which shows the closest correspondence between the changes in atmospheric pressure and the rise and fall of the waters.

The Mound-Builders and the Southern Indians.—Dr. Daniel G. Brinton has sought to answer the question, Who were the mound-builders? by inquiring whether and to what extent the tribes who inhabited the Mississippi Valley and the Atlantic slope were accustomed to make works similar to the mounds. It is clear, from several accounts, that the Iroquois were accustomed to construct burial-mounds, and their neighbors, the various Algonquin tribes, occasionally raised heaps of soil. The Cherokees do not appear to have been real mound-builders, but they appreciated the convenience of mounds, and put their more important buildings upon them when they had them at hand. The tribes among whom we can look for the descendants of the mound-builders with the greatest probability of success are the tribes of the great Chahta-Muskokee family, which includes the Choctaws, Chickasaws, Creeks, Seminoles, and Natchez. They "seem to have been a building race, and to have reared tumuli not contemptible in comparison even with the mightiest of the Ohio Valley." Cabeza de Vaca, who accompanied the expedition of Pamfilo de Narvaez in 1527, mentions a place where the natives were accustomed to erect their dwellings on a steep hill, and dig a ditch around its base, as a means of defense. All the accounts of those who participated in Hernando de Soto's expedition describe the Southern tribes as constructing artificial mounds, using earthworks for defense, excavating ditches and canals, etc. Thus, La Vega tells how the caciques in Florida formed earth into a kind of platform "two or three pikes in height, the summit of which is large enough to give room for twelve, fifteen, or twenty houses, to lodge the cacique and his attendants. At the foot of this elevation they mark out a square place, according to the size of the village, around which the leading men have their houses." Biedma says that the caciques of a certain region "were accustomed to erect near the house very high mounds (*tertres tres-élevées*), and there were some who placed their houses on the top of these mounds." The Huguenots who attempted to settle in Florida described similar structures as marking the sites of the houses of the chief. William Bartram, the botanist, who visited the Creeks in the last century, found that they had "chunk-yards" surrounded by low mounds of earth, at one end of which, sometimes on a moderate artificial elevation, was the chief's dwelling, and at the other end the public council-house. Large burial-mounds are also often spoken of as being made by these tribes. Many of the mounds in the Gulf States are very large. One in the Etowah Valley, Georgia, has a capacity of one million cubic feet. The Messier mound, near the Chattahoochee River, contains about seven hundred thousand cubic feet, and is twice as large as the great mound near Miamisburg, Ohio. Dr. Brinton's views are parallel, if not identical, with those worked out by the late Mr. Lewis H. Morgan, in his "Houses and House-Life of the American Aborigines."

The Microbe of Malaria.—M. Richard, a French pathologist, announces that he has discovered the parasite of malaria in a microbe which makes its special habitat in the red globule of the blood, where it is developed in a similar manner with the weevil in the bean, and whence it issues as soon as it has reached the perfect state. When the blood of a patient suffering from an attack of fever is examined, red globules will be

found, having a little round, clear spot in their depth, but which otherwise preserve all the appearance and elasticity of the normal red globules; they are simply, if the expression may be allowed, stung. Besides these globules, others exist in which the evolution of the microbe is more advanced; the clear spot has become larger, and is surrounded as if by a setting of fine black granulations; all around, the hemoglobine, plainly distinguishable by its greenish-yellow tint, forms a ring, which grows narrower as the parasite increases in volume. At last, nothing is left of it but a perfectly colorless, narrow marginal zone, the hemoglobine having entirely disappeared, and the substance of the red globule having been taken possession of by the microbe till it has been reduced to a shell. We now have a circular element having nearly the dimensions of the red globule, and inclosing the microbe, which has reached its perfect condition, and is provided with one or more very slender prolongations, which are, however, not visible in this condition. At this moment the parasite is about to pierce the membrane that contains it, and escape into the plasma of the blood. This microbe can be found in every patient about to be attacked with fever, except those suffering from marsh-cachexy, concerning whom M. Richard can not speak decidedly, because he has not made sufficient examinations of them.

Geological Influences in English History.—Professor Archibald Geikie has an article in "Macmillan's Magazine" illustrating how the history of the English people has been affected by the geological structure of their island. That the relation thus assumed is real may be proved by viewing the contrast between the heart of England and the heart of Scotland. The former is inhabited by a rich agricultural or busy mining English-speaking population, is dotted with large cities, and teems in every element with the bustle of enterprise; the latter, a region of rugged mountains and narrow glens, is tenanted by a Celtic race that clings to its old tongue and habits, has never built towns and hardly villages, abounds in pastures and game-lands, but has no industrial centers, no manufactures of any kind, and only a feeble agriculture struggling for existence along the bottoms of the valleys. These differences prove, upon examination, to have arisen fundamentally from the utterly distinct geological structure of the two regions, by which diversities in human characteristics were initiated in far prehistoric times, and have been continued, in spite of the blending influences of modern civilization, down to the present day. Passing by the conjectures as to what may have happened in prehistoric times, and between the Cymric and Gaelic branches of the Celtic race, we come to the Roman conquest, which was extended over the lowland regions of the Old Red Sandstone and Carboniferons strata of England and Scotland, and was stopped at the crystalline rocks of the Highlands. The same geological influences which guided the progress of the Roman armies may be traced in the subsequent Teutonic invasions of Angles, Saxons, Jutes, and Norwegians. It was on the former platforms of undisturbed strata "that invaders could most successfully establish themselves. So dominant has been this geological influence, that the line of boundary between the crystalline rocks and the Old Red Sandstone, from the north of Caithness to the coast of Kincardineshire, was almost precisely that of the frontier established between the old Celtic natives and the later hordes of Danes and Northmen. To this day, in spite of the inevitable commingling of the races, it still serves to define the respective areas of the Gaelic-speaking and English-speaking populations." On the northwestern coasts of the island there are none of the fringes of more recent formations which have had so marked an influence on the eastern side. Hence, though the Norsemen possessed themselves of every available bay and inlet, driving the Celts into the more barren interior, the natural contours made it impossible that their hold on the ground should be so firm as that of their kinsmen on the east. Hence the Gaels eventually came down upon them, and all obvious trace of the Norse occupation disappeared, save in the names given by the sea-rovers to the islands, promontories, and inlets. The difference in the character of the Irish and the Highlanders—both Celts—may be traced to differences in geological structure and scenery. The Irishman is

light-hearted and impulsive, because he lives in an easy country, with a soft climate and rich soil. The Highlander is rugged and stern, because his country, where "he has to fight with the elements a never-ending battle, wherein he is often the loser," is so. The apportionment of lands into cultivated, pasture, and feral lands, rests upon geological causes, which determine that each tract shall be used for the purposes by which the most can be made out of it. The sites of towns and villages may often be traced to a similar influence. Formerly they were built around heights that could be fortified; now they are built where the geological features afford the most scope for industrial and commercial development; and the latter towns are the ones that are growing, and to which the population is being transferred at the expense of the others. The style of architecture, which is largely determined by the presence or absence of building-stone, and the kind of the stone or clay, is obviously related to geological features. Lastly, "the history of the development of our system of railways, our steam machinery, our manufactures, is unintelligible except when taken together with the opening up of our resources in coal and iron," and these are traceable wholly to geological features.

A New Weighing of the Earth.—Professor von Jolly, of Munich, has recently employed a new process for the determination of the mean density of the earth. He placed a pair of scales in the top of a tower, and attached to each plate of the instrument a wire which reached, passing through a zinc tube, to twenty-one metres below. To the lower ends of the wires other scale plates were suspended, which thus hung within a little more than a metre of the ground. Under one of the lower plates he put a ball of lead, a metre in diameter. The fact that a body at a certain elevation gains in weight as it is brought nearer to the ground was verified by weighing bodies first in one of the upper balances and then in one of the lower ones. Furthermore these bodies varied in weight in the lower plates according as the mass of lead remained under them or was taken away. The differences in these weights showed the degree of attraction exercised by the mass. The value thus obtained, compared with the attraction exerted by the earth alone, furnished a means of ascertaining, according to the laws of gravitation, the ratio between the density of the earth and that of lead, and, the latter being known, of determining the mean density of the globe. M. von Jolly's experiments give this density as 5·692, with a probable error of ±0·068, a figure that agrees quite well with other determinations, particularly with Bailey's of 5·67.

Recent Applications of Science to Machinery.—Sir Frederick Bramwell took as the subject of his chairman's address at the recent opening of the 128th session of the Society of Arts, the later applications of science to the promotion of arts, manufactures, and commerce. It could not be said, he remarked, that any new scientific discovery or principle has been applied to the steam-engine, which is still our pre-eminent motor, but the principles on which its economical action depends have been advanced by the application of jacketing for saving steam and the use of higher pressures, with a consequent economy of coal. Available pressures have increased during the last half-century from three and a half pounds to one hundred pounds; and Mr. Loftus Perkins has engines running with four hundred pounds of pressure above that of the atmosphere, demanding a consumption of one and two thirds of a pound of coal per indicated horse-power per hour against two and a half pounds required by engines using a pressure of one hundred pounds. The saving, five sixths of a pound, seems small when expressed in simple figures, but it represents a considerable percentage, and the difference between running a vessel fourteen days and twenty-one days with the same stock of coal. Nevertheless, unless some wholly new and at present undreamed-of discovery is made, the steam-engine will have to yield its place to other means of obtaining motive power. The average of British engines do not give forth one twenty-fifth of the energy that may be considered as residing in the fuel they consume; and even if we should obtain a horse-power per hour for as little as one pound of coal, we should still utilize only about a sixth or a fifth of that energy. The opera-

tion of railways has been improved by the introduction of steel rails, the extension of the block and interlocking systems, the application of continuous brakes, and the better adaptation of rolling-stock to turning curves; and the use of steel for crossties is anticipated. Arrangements are in use by which the signal-man can cause the whistle of the engine to sound at the same time he gives the danger-signal; and a device to enable him also to turn off the steam, apply the brakes, and stop the train is desirable and not impracticable; but this should be accompanied with a registering apparatus to reveal the negligence of the engineer that may have made it necessary to apply it. So much has been gained in our knowledge of the theory of resistance and the best dimensions and shapes of ships, that we are now able to build vessels approaching the size of the Great Eastern, and run them with a profit at a greater speed than was ever attained before. Gas-engines are made, the workings of which are nearly as steady as those of the steam-engine, and with Mr. Dowson's process for making fuel-gas, power can now be obtained from gas-fuel for less cost than in the ordinary steam-engine. A curious application of shifting ballast, which was once thought to be one of the most dangerous agents to equilibrium, has been made in the British war-vessel Inflexible to check the rolling of the vessel. Water, in a tank extending across the vessel, by being on the lower side at the moment the vessel turns to roll upon the other side, and remaining there till the position of equilibrium is reached, restrains the violence of the oscillation, diminishes its extent, and tends to bring the vessel sooner to rest.

Scientific Societies in Japan.—Besides having several bodies in the nature of learned societies which have enjoyed a time-honored existence, the Japanese have been prompted, under the impulse given by the introduction of European culture, to found several new scientific associations. The most important of these bodies is the Geographical Society of Tokio, with two hundred members, among whom are included several of the chief personages of the empire. Its "Transactions" are neatly printed in pamphlets of about one hundred pages each, and contain much matter, especially the papers relating to Corea, that is valuable to European geographers. A biological society was established while Professor Morse, of Salem, Massachusetts, was connected with the University of Tokio, and is now conducted by Professor Yatahe, a scholar educated in the United States. The *Kojunsha*, or Society for the Circulation of Knowledge, has branches in nearly every town of importance in the empire. A member desiring information on any subject applies to the secretary, who finds on his books the names of any persons who are likely to satisfy the applicant, and transmits his questions to him. The answers are forwarded to the inquirer, and, if important enough, are printed in the weekly "Journal" of the society. This association has nearly three thousand members, some of them in Europe and America. The Seismological Society has been instituted for the study of earthquakes, for which Japan offers rare facilities. It is given the use of the telegraphs by the Government for the instantaneous transmission of news of phenomena happening in any part of the country. The Numismatic Society, one of the old native societies, is very active, and publishes a periodical describing the new and strange coins that are exhibited at its meetings. The Antiquarian Society and the Society of *Go*-players are also ancient native organizations that still flourish.

A New Race in Course of Development.—M. Gustave Le Bon has called attention to a peculiar race living in the Tatras Mountains, the process of whose formation out of the neighboring peoples, from whom it is now isolated, he believes can be traced quite clearly. It is the people called the Podolians. They are surrounded on different sides by Ruthenians, Slovacks, Magyars, Germans, and other races, yet are distinct from them in many of the most essential characteristics. Their land is walled by a circle of mountains difficult to traverse, which interpose an effectual physical separation between them and the races dwelling on the other side; the climate is rigorous, the soil poor, and adapted to the production of so limited a

number of crops that their food is almost entirely confined to oatmeal, and milk, or its products. Under such conditions only the most vigorous children can survive; consequently a natural selection has been going on for centuries, by the operation of which the people have acquired a superior stature and cranial capacity. The legends and traditions go back to a period when the people's ancestors were all brigands, and were at the same time very religious, and when their moral and religious sentiments were wholly independent of each other, or, we might say, contradictory. They were accustomed never to start off on a predatory expedition without invoking God and the saints for the success of the enterprise, and the legends are full of testimonies of the protection that Heaven accorded to the robbers. The Church of St. Anne, at Nowy Targ, it is said, was built by thieves as a thank-offering for the care the Lord took of them in one of their expeditions! The population appears to have been produced from crosses of the neighboring races, which ceased after it became considerable enough to take care of itself, and it has consolidated its traits under the immediate influences of its environment. The Podolian territory, protected by its inclosure of steep mountains, was in the old times the refuge of the outlaws of the neighboring country, who met there and laid the foundations of the present race. The chief element in the composition was probably furnished by Poles, whom the Podolians resemble in psychological traits and language more than they do their other neighbors. Next in importance, perhaps, were the Slovacks, with whom linguistic affinities are traceable. The mental traits, tastes, and culture of the Podolians are peculiar, and in some respects incongruous with the conditions of their life. They are addicted to letters, music, and poetry, and are very religious. The only one of the races around them that share these tastes is the Ruthenians, but they are at the same time capricious in disposition, and lacking in energy, activity, and perseverance, while the Podolians are the opposite. We must infer, then, that the Podolians derive their refined tastes by inheritance from Ruthenian ancestors, while their more vigorous qualities have been developed under the influence of the struggles which they have had to maintain with the physical conditions of their country. The superior cranial capacity of the Podolians, which is remarkable, is likewise probably owing to the constant draft which circumstances have made upon their resources and the activity of their intelligence.

Fossil Insects.—Mr. H. Goss has recently concluded a series of papers reviewing the studies of several paleontologists in fossil insects. The hexapod insects constitute, after the crustaceans, the most numerous class of ancient articulates with which we are acquainted. Remains of their wings, quite distinguishable, are found in the Devonian formations of America and the Carboniferous of Europe. Myriapods appear first in the Trias; and Arachnids had not, until scorpions were recently discovered in the Carboniferous of Scotland, been found below the Jurassic. The two most ancient insects known are two which Mr. Scudder has described from the fern-marked Devonian strata of New Brunswick, one of which is allied with the *Neuroptera*, or dragon-flies, the other with the *Orthoptera*. These classes seem to have the field to themselves till the Carboniferous period, when the *Hemiptera* and *Coleoptera* (and our Scottish scorpion) first appear. The most common insects of the Palæozoic and Mesozoic epochs appear to be of the family of the cockroaches, which are very abundant in both continents, and which Mr. Scudder has made the subject of a special monograph. Insect remains become more abundant in the Jurassic epoch. A certain limestone of the English Lias is so full of them that it is called the insect limestone. The *Coleoptera* are most numerous, probably because their horny elytræ better resist decay, but *Hymenoptera* and *Diptera* also are found at Solenhofen and Purbeck. The cretaceous and tertiary beds, however, have furnished the largest number of specimens that have been studied by paleontologists, the multiplication of insects having, it seems, been greatly favored by the prevalence of angiospermous vegetation. The *Lepidoptera* appear last, and are rare, not more than ten authentic types of them having been recognized. Certain beds, such as those of Solenhofen, Aix in Provence,

Œningen in Switzerland, Radoboj in Hungary, Monte Balca in Italy, and the Florissant basin in Colorado, are celebrated for the rich harvests of insects they afford. The nature of the deposits seems to have exercised some influence upon the greater or less frequency of certain types, for each of these beds is distinguished by the prevalence of particular types. Elytræ are found in quaternary beds, which have largely preserved their metallic luster. A curculioform found in England has a tropical grandeur of size. Most of the later fossil species on the Continent are identical with those now living in Europe. Fossil insects present but few of those strange gigantic forms that astonish us among the other classes of animal remains. The largest and most curious forms found are still surpassed in tropical countries. The insects which occur in the Lias, among the remains of monstrous pterodactyls and extinct saurians, are all of families that are still represented in life; and the oldest insects of the Devonian could be inserted among living *Orthoptera* without disturbing the symmetry of the order.

Sewage-Irrigation in German Cities.—M. Durand-Claye, a sanitary engineer of Paris, has published a report on the systems which are employed in the German cities of Dantzic, Berlin, and Breslau, for the final disposal of sewer-water. The systems of filtering and of precipitation by chemical agents were tried, but were found not to effect a sufficient purification; and irrigation was finally chosen as furnishing on the whole the most economical and satisfactory method. The water is cleansed of its grosser solids before being pumped up from the sewers; it is afterward conducted to the irrigated tracts. At Dantzic, the sewage is turned upon a tract of about twelve hundred and fifty acres of a sandy, arid soil, and is led around beds devoted to the culture of garden vegetables. The surplus water, which is drained off to the Vistula, has been proved to have lost seven eighths of its organic matter, five sixths of its ammonia, and one half of its mineral impurities. The ground has an excessive absorbing power, and it has been necessary to box the main conduits to have any water left for the smaller irrigating channels. Thus far, four hundred and seventeen acres have been enough to absorb all the sewage of the city, indicating an absorbing-power of thirty-two thousand cubic metres a year for each acre. The works have been made and are kept up without cost to the city, for the use of the irrigated lands for thirty years; and the land is sublet to gardeners for from twenty to twenty-eight dollars an acre. The mortality of the city—one of about one hundred thousand inhabitants—has been reduced twenty-one per cent under the operation of this system. At Berlin, after some unsatisfactory experiments with chemical agents, irrigation was tried on about fifteen acres of land. The tract took in and purified 231·618 cubic metres of water in a year and nine months, and returned good crops. The municipality determined to treat all of its sewer-waters in the same way, and bought two tracts, one of seventeen hundred and forty acres, the other, at Osdorf and Friederickenhof, of two thousand and sixty acres. One thousand and eighty acres of the latter tract only have been used. In addition to the cultivated plats, drained basins are provided for the water that is not needed on the crops, in which, after a deposit about a foot thick has accumulated, the ground is dried, dug up, and made ready for cultivation in the next year. The waters thus treated cease to give off odors and lose all unhygienic properties; the health of the workmen and the comfortable occupation of the neighboring country seats are not affected by them. The cost of managing the lands is defrayed by the sale of products, so that the city is only at the expense of pumping up the water, while it is able to let the lands at from twenty-four to thirty-four dollars an acre. The city of Breslau uses a tract of about twelve hundred acres, of such a character that extra drainage is necessary. The irrigated lands are let to the engineer who constructed the works at a scale of rents which is to rise in four years to eighteen dollars an acre.

The Salt Deposits of the Persian Gulf.—On the eastern side of the Persian Gulf is an extensive area containing a large deposit of salt which crops out at various

places and rises into ranges of rocks of considerable magnitude. The salt-bearing rocks are of a reddish color, receiving their tint from red ochre, which, associated to a small extent with specular iron, covers the salt deposit and is more or less mixed with it, imparting to it also a red tint. The association of ochre with salt is so constant in the district that the existence of the former is almost a sure indication of the presence of the latter. Near the villlage of Kowin on the Island of Kishm, the salt and ochre are so mingled in a part of the range as to give it the appearance of a structure made of red bricks and mortar. Years ago, the salt was gathered from hollows in the ground where briny water issuing from the rocks could be collected and the mineral would be left after evaporation in beautiful crystalline masses. More recently, the salt has been quarried; and the works conducted for this purpose have become large caverns in which stalactites have been formed from the trickling of the brine, yielding snow-white masses of saccharoid salt. Besides these masses, the salt is found here in pure white lumps, easily reduced to granules, the most valuable form, red, stony masses which are used chiefly for salting fish, and translucent and transparent masses of cubical forms, and is dug out with crow-bars. At Hameran, four miles from the sea-shore, the salt is found in beds about four feet thick with intervening layers of earthy material, and is sometimes of a pale-greenish color from contact with an earth containing manganese. The masses in these beds are broken with gunpowder and granulated with mallets. Warm springs charged with salt are found close by the village of Salakh, near Henjam, yielding a reddish naphtha which the natives use for purposes of light and for rheumatic complaints.

The Great Arctic Forest.—Professor Nordenskiold, in his "Voyage of the Vega," describes what he calls the greatest forest the earth has to show. It exists in the country of the Yenisei River, and extends from the fifty-eighth or fifty-ninth degree of latitude to far north of the Arctic Circle, in the neighborhood of the sixty-ninth degree of latitude, covering an extent of about one thousand kilometres from north to south, and perhaps four times as much from east to west. "It is," he says, "a primeval forest of enormous extent, nearly untouched by the axe of the cultivator, but at many places devastated by forest-fires. On the high eastern bank of the Yenisei the forest begins immediately at the river-bank. It consists principally of pines. . . . Most of these already north of the Arctic Circle [the traveler is supposed to be going from north to south] reach a colossal size, but in such a case are often here, far from all forestry, gray and half-dried up with age." The ground is covered with fallen branches and stems in all stages of rottenness, which are covered, often concealed, by an exceedingly luxuriant bed of mosses, while tree-lichens occur sparingly. "The pines, therefore, want the shaggy covering common in Sweden, and the bark of the birches which are seen here and there among the pines is distinguished by an uncommon blinding whiteness." Evidence was collected to show that the limit of trees in the Yenisei region has extended, even during our geological period, farther north than now.

Mud-Volcanoes in Sicily.—Two eruptions of mud in places remote from each other, and offering different and remarkable characteristics, are under observation in Sicily. One is taking place in the interior of the island, about eight miles north of Girgenti. It proceeds from a mountain about three hundred feet high, called Macaluba, the flattened summit of which is dotted with small cones, each containing a tunnel-shaped crater, from the bottom of which a bubble of mud rises and bursts every minute. The other eruption is near Paterno, on the western side of the lower region of Etna, nearly forty miles west of Macaluba, and takes place in openings and small cones on the level of the surface. It is considerably more violent than that of Macaluba. The mud spurts out in jets several yards high, and forms a large fuming lake, which runs into the bed of the river Sinet. The eruption has been renewed three times within a year, and is at present accompanied with deep subterranean rumblings and strong tremors of the earth, some of which are perceptible several miles away. The mud that issues from these volcanoes is saline

and petroleum-bearing. A kind of scum of petroleum may be seen on the edges of the craters of Macaluba. The gases escaping from them contain from thirty-four to thirty-six per cent of carburetted hydrogen, with sulphuretted hydrogen and carbonic acid. The soil around Paterno, in which the center of the second eruption is situated, is calcareous, and abounds in springs containing carbonic acid. The waters, infiltrating the soil, raise its temperature and form a kind of veined alabaster, which is much esteemed. The eruptions are occasioned by the passage of carburetted hydrogen, which is formed by the decomposition of organic matters within the earth, in seeking its way to the surface through beds of clay which have been washed down into the crevices. Mud-volcanoes of another kind, of which those of New Zealand and Iceland afford examples, are formed by vapors of water proceeding from ordinary volcanoes, and are distinguished by the high temperature of the mud and the absence of carburetted hydrogen.

The Oldest Flowering Plant.—MM. G. de Saporta and A. F. Marion have been studying the genera *Williamsonia* and *Goniolina*, the most ancient angiospermous plants of which the fructiferous organs have been preserved. The stem bears at its extremity reproductive apparatus in which two different modes of structure, indicating a dicœcious plant, may be distinguished. A many-leaved involucre, having its bracts so curved as to give it a globular appearance, is observed in every case. The parts of the male involucre are disposed in a single row, connivent, elongated, and attenuated at the end. The organ represents a conical axis, the base of which is surrounded with a circular zone marked with radiating striæ. The outer edge of this zone, when it is exposed, is occupied with a collection of very small compartments of irregular hexagonal contour, that seem to represent as many pollen-boxes. This basilar zone corresponded with a sterile and persistent portion of the androphore, which in its integrity probably covered the whole conical receptacle with a matted layer of staminal appendages, recalling by their disposition and office the male organs of the *Typhas*. The female organs of the *Williamsonia* are provided with the globose involucre of the male flower, except that the bracts are a little shorter. The organ contained within this involucre, which was certainly caducous at maturity, consisted of a receptacle or spadix in the form of a more or less globose solid cushion. The central leaves of the involucre, which remain in place, testify by their thickness to a particularly tough primitive condition. The spadix in the midst of them is covered on its upper part with carpellary compartments, while the fibro-ligneous tissue which composed the axis of the receptacle is recognizable in the lower part.

French Exploring Expeditions.—Since 1874 the French Government has authorized the organization of three hundred and thirty scientific missions, of which one hundred and sixty-eight were to operate in Europe, fifty-four in Africa, forty-eight in Asia, thirty-six in America, and twenty-four in Oceania. Most of these missions are still at work, and generally report to a commission appointed by the Minister of Public Instruction. The "Revue Scientifique" reviews the condition of the most important of the missions, particularly of those which relate especially to geography. M. Lantz is in Madagascar, studying the natural history of the less accessible parts of the island; M. Pélagaud is exploring the Mascarene Islands; M. Montano, Malaysia; and M. Marché, the Philippine Islands. In Africa, M. Mathcis is exploring the region between the Niger and the Bénoué; M. Revoil is examining the Somauli country from Cape Guardafui to the Strait of Bab-el-Mandeb; Messrs. Savorgnan de Brazza and Ballay are supplementing Stanley's work on the Congo; Messrs. Roux, Cagnat, and Gosselin are studying the geography and archæology of Tunisia; M. Galliéni has concluded a treaty for the navigation of the Niger to Timbuctoo; and several expeditions are engaged in the eastern part of the continent. In Asia, M. Haas is pursuing artistic and historical investigations in Hindostan; M. Chantre has started from Bagdad to look into the anthropology and zoölogy of the region of the Caspian Sea and Mount Ararat; M. Clermont-Ganneau is engaged in archæological work in the east of

Egypt, in Philistia, and Phœnicia; M. Cotteau is making his way through Russia and Siberia to Japan. M. Wiener is traveling through South America; M. Pinard, having done some work in Alaska, is engaged in California, New Mexico, and Arizona; and M. Charnay is digging in the ruins of the ancient cities of Mexico. In Europe, M. Georges Pouchet is studying the glacial fauna of Norway; M. Dieulafait is investigating the formation of rock-salts and gypsums in Switzerland; M. Milne-Edwards, as the head of a commission, is about to engage in deep-sea researches in the Mediterranean; and several parties are exploring the Alps and the Pyrenees.

Is the Moon red-hot?—Mr. W. Mattieu Williams believes that the surface of the moon has an intrinsic brilliancy of its own, and a temperature much greater than is usually supposed. He expresses the opinion, in effect, that the surface of the moon is, as it appears to be in eclipses, "of a dull-red heat, and that this high temperature is due to the action of the sun's rays striking it directly, without any intervening shield of aqueous vapor or other atmospheric matter. If the volcanic tufa, of which the moon's surface is evidently composed, resembles the corresponding material on our earth, it is one of the best absorbers of heat and the worst of conductors. This being the case, the uninterrupted glare of the sun's rays would produce its maximum possible effect on a thin film of the moon's surface. . . . We must remember that a dull copper-red heat, just visible in the dark, is considerably below the temperature of red heat visible in daylight. Supposing the color of the moon to be due to such heat, I should estimate its surface temperature at a little above 600°." Lord Rosse, estimating the surface temperature of the moon, concluded it was about 500°. Mr. Williams was led to his conclusion by watching the appearance of the moon during the totality of an eclipse. When the partially eclipsed moon rose, the shaded part displayed a full copper-red color; as the eclipse progressed, this advanced to a darker or more obscure copper-color; then the redness gradually faded, and the shaded portion of the moon grew darker and grayer, until at last it became of a dark slate-color; and its outline or limb was barely traceable toward the end of the eclipse. In some elementary treatises this copper-color is attributed to "the refraction of the sun's light by the action of the earth." Mr. Williams fails to see how this can operate in the middle of the shadow, where the color is the most decided, and why it should fade as the eclipse progresses, and finally be lost just at the outer edge of the shadow. The fading is easily accounted for on Mr. Williams's hypothesis, as the result of the rapid cooling of the lunar surface on the withdrawal of the sun's rays. The reasoning that ascribes so high a temperature to the side of the moon presented to the sun must lead to the conclusion that the dark, or night side, is intensely cold.

The Original Home of the Aryans.—Dr. Fligier argues in "Kosmos" that the theory of the Asiatic origin of the Aryan race is not yet as firmly settled as has been supposed. Latham disputes it on geographical grounds in his "Native Races of the Russian Empire." Pictet believes, on the evidence of the names of animals and plants that were known to them, that they originated farther north than the Asiatic theory supposes, and fixes their birthplace in Southern Russia. Benfey and Professor Tomaschek, of Grätz, agree with him, and indicate the region of the southern Volga as their primary home, whence they may have spread to the Carpathian Mountains on the west, and to the marshes of the interior and the Ural on the east. Bogdanoff has found dolichocephalous skulls of the recognized type of the German giant-graves in the Kurgans of Moscow. Resemblances between Finnish and Aryan and between Magyar and Iranian words indicate that those people were respectively neighbors to each other in their old times, as might have been the case if the theory of the European origin of the Aryans is true. Dr. Fligier believes that the results of linguistic, anthropological, and archæological researches indicate that the Indians and the Iranians lived near each other for a long time in Eastern Europe or Northwestern Asia, and that the Indians followed the Iranians into Asia. That this happened at a comparatively late period is presumed to be shown by the fact that these

peoples are not mentioned in the older Babylonian cuneiform inscriptions, and are first spoken of in the Assyrian inscriptions of the ninth century B. C. A second Aryan emigration to Asia followed across the Hellespont. After making a detailed examination of the Aryan stocks and their supposed emigrations, Dr. Fligier concludes that their linguistic unity does not by any means constitute an anthropological unity: the Asiatic Aryans have partly lost their Aryan type, and the European Aryans present two quite distinct types.

Observations of the Last Solar Eclipse.—The solar eclipse of May 19th has been the subject of a number of communications to the French Academy of Sciences. M. Janssen spoke in terms of admiration of the photographs of all the phases of the phenomenon which were obtained by means of the photographic revolver. A very laconic notice of the observations made during totality by Messrs. Trépied, Lockyer, Thollon, and Tacchini, was sent by telegraph. The Egyptian Government gave exceptional facilities to the observers. Photographs of the corona and its spectrum were obtained, the latter exhibiting the lines of potassium and hydrogen. The observers at the same time noticed a comet which was visible to the naked eye in the immediate vicinity of the sun. At Lyons M. André and his aids saw between the edge of the moon and the outline of the sun-spots which it was approaching, the development of the gray ligament that has been noticed between the edge of the sun and the circumference of the planets crossing its disk. The popular observatory of the Trocadéro, in Paris, on the day of the eclipse, put four telescopes, as many opera-glasses, and blackened glasses, at the service of the public. About a hundred persons were present as early as six o'clock in the morning. Each instrument was in charge of an assistant, whose duty it was to help the public to see the phenomenon. One of the assistants made a projection apparatus of his telescope, and threw an image of the eclipse and of numerous solar spots upon a screen, where it could easily be looked at by fifteen persons at once. It was thus made possible to examine with the microscope the details of a considerable number of spots, and to see the black profiles of the lunar mountains designed on the illuminated image of the sun. Several drawings of the solar spots and the eclipse were taken.

An Insect-lodging Flower.—M. Treub has made a study in Java of the *Discidia Rafflesia*, a curious plant which lives upon trees without touching the ground. It produces urns in the shape of jars open at the top, and containing within a system of branched roots. After showing that these formations are produced by the folding of a leaf upon itself in such a manner that its lower face corresponds with the interior face of the urn, M. Treub inquires what may be the office of the organs. The fact that the interior of the urn is lined with a waxy coating precludes the idea that it can directly serve a carnivorous purpose. Against this, too, are the facts alleged by M. Treub, that ants which are found in the urn are always very lively and generally very numerous; that they come out of the urn as easily as they go into it; and that they swarm in it to such an extent that the roots suffer from them, and the radicels are eaten or are very weak. These insects, then, seem rather to devour the discidia than to serve it as food. M. Treub concludes that "the urns of the discidia are of no use to it as traps for insects. The plant is not in any sense carnivorous. Instead of falling into an ambuscade, the ants that enter an urn find there a lodging that suits them marvelously. The principal, if not the sole, function of the urn is to collect, or, in a lesser degree, to save water." M. Treub shows further that the water in the urns is generally rain-water, more rarely transpired water, that may perhaps be afterward reabsorbed by the plant.

Calculating the Area of the United States.—Mr. F. Y. Carpenter, C. E., has explained in "Van Nostrand's Engineering Magazine" the difficulties which are encountered in making an accurate computation of the area of a large country like the United States, having irregular boundary-lines. The principal difficulty arises from the indeterminateness of the expression, "our territorial outline." The place, even, of the sea-line

is not fixed. Tradition, not law, sets it at three miles out from shore, but the Spaniards in Cuba have claimed six miles, and most nations now have guns capable of enforcing their jurisdiction over that distance. It is impossible to determine by a fixed rule what waters between headlands shall be included as a part of the territory. It seems obviously proper to include landlocked bodies of water; but should Lake Michigan be admitted to this category? Mr. Carpenter decides that it should. A convention between France and England made in 1839 defined the coast-line as one that should cross the mouths of all bays and channels not more than ten miles in width This would exclude Chesapeake Bay, which is fifteen miles wide at its mouth, but is evidently as much a part of the United States as Seneca Lake. Lords Hale and Hawkins would have had the ocean boundary cross such inlets as are so narrow that "a man may reasonably discern from shore to shore"; and Justice Story thought the vision should be required to be distinct and with the naked eye; Wheaton would include the ports, harbors, bays, mouths of rivers, and adjacent parts of the sea inclosed by headlands; and Willcock, saying that it may be regarded as generally accepted that bays or channels within the horns of promontories, however large, are subject to the sovereign of the neighboring land, has given a definition under which our Atlantic coast might be considered to extend in a straight line from Maine to Florida. The effect of elevation over the sea upon the area of a tract is also considered by Mr. Carpenter. All tracts the measurement of which is taken in degrees and minutes, gain in extent as their height above the sea is increased, for they are there a part of a larger sphere than one whose perimeter is defined at the normal level. Colorado, having a mean elevation of 7,050 feet, is estimated to gain in consequence 44,800 acres, or seventy square miles. Estimating the mean altitude of the whole United States at 2,600 feet, the country is 800 square miles larger than it would be if it were all down at the level of the sea. A district or country otherwise gains in superficial area of land if it is mountainous, by reason of the slope of its hills. It is impracticable as yet to determine the actual gain from this source for any State; but if Colorado is supposed to have an average slope of ten degrees, it gains an additional area of 1,600 square miles; if its slope is five degrees, its gain is 400 square miles. Taking a mean of these figures, it seems safe to say that Colorado is indebted to its mountains for at least one thousand square miles of area, which has never yet been included in any statement of its geographical extent.

Tastes and Smells in Water.—Dr. William Ripley Nichols, in a paper on "The Tastes and Odors of Surface Waters," calls attention to the desirability of competent persons trained to scientific observation undertaking systematic daily examinations of the water in reservoirs for long periods of time—say for five years—to watch the changes that take place in its condition and the causes of them. He also notices that the means by which water may be made unpleasant are numerous and complicated, and are not always animal in their origin. The worst smell that he ever obtained was from allowing the seed parts of a species of *Potamogeton* to decay in water. Professor Brewer has obtained a fishy odor from the decay in water of the leaf-stalks of a pickerel-weed. Sometimes the odors and tastes from various plants differing from each other seem to blend into a more or less marshy or pond flavor. The water of ponds and lakes that are surrrounded by woods acquires more of a bitter or astringent taste, that may be referred to the dead leaves. When a recently felled tree is exposed to the action of water, or when bushes or grass and weeds are killed by being flooded, the sap and more soluble matters are leached out and putrefy or undergo other forms of decomposition. If the matter is alternately flooded and left bare, decay takes place fast. As the level is lowered, those aquatic plants which grow in shallow water die, and if the water rises after a short interval it becomes impregnated with the products of their decay. If a considerable interval elapses, land-plants grow upon the exposed surface, and, being drowned by the rising waters, tend to its contamination in the same manner. The substances which form the most offensive

part of the soluble vegetable matter are albuminous in character, and the chemical effect on the water is to increase the amount of what is called "albuminoid ammonia." No doubt dead fishes and animalcules and their excrement add to the nitrogenous organic matter in surface-waters, but their presence is not necessary to account for bad odors. As a rule, in waters not contaminated with sewage, the animal matter forms only a trifling proportion of the entire organic matter, but the recent investigation of Professor Remsen shows that in some instances the animal matter, as from sponges, may be appreciable and of practical importance.

Old and New Latitudes on the Atlantic Coast.—The Rev. Edmund F. Slafter, of the New England Historic Genealogical Society, has published an inquiry into the history and causes of the incorrect latitudes as recorded in the journals of the early writers, navigators, and explorers relating to the Atlantic coast of North America. After giving comparisons of the old with the new and corrected latitudes of a considerable number of places, he sums up his conclusions that the early latitudes are generally trustworthy to within a single degree; that the minutes or fractions of degrees as set down by writers anterior to the middle of the eighteenth century are never to be relied upon, and are never correct, except by accident; and that the annotations of commentators upon the latitudes recorded in the journals of our early navigators and explorers, in all cases in which they attempt to identify places within the limit of one degree by the latitude alone, can not properly be cited as authority. The sources of the errors of latitude to which attention is thus directed are not far to seek. The instruments possessed by the earlier navigators were of the rudest and coarsest character. They were graduated in degrees only, of which each degree occupied but about one tenth of an inch of space, and the attempt to subdivide this space into sixty parts, for minutes, would have been impossible if it had been made. So, putting down the fractions of degrees, or minutes, was an absolute and sheer guess. In the old journals the minutes are usually written in fractions of a degree, as one fourth, one third, one half, two thirds, or three fourths, and sometimes translated into minutes, and given as fifteen, twenty, thirty, forty, or forty-five minutes, but very rarely in any number of minutes not represented by these general fractions. The zodiacal ephemeris, moreover, was not graduated in minutes, and consequently inaccuracy existed as to the exact point of the sun in the zodiac at the time of taking the latitude. The tables used in connection with this instrument, moreover, were not calculated oftener than once in thirty years, so that they became obsolete long before they were put away, by reason of the precession of the equinoxes. Several other sources of error of minor importance, now always allowed for, were neglected in those days. "If the latitudes of the early navigators," the writer adds, "had been determined with as much accuracy as is attained by the observations of the present day, some interesting historical questions might have been settled, and some not very decisive controversies might have been avoided."

Word-Blindness.—M. Armaignac has described a curious case of persistent "word-blindness." The sufferer is and always has been in the full enjoyment of his intellectual faculties; he has never had any trouble in his speech or from paralysis; and he writes correctly, in a regular and elegant hand, whatever is dictated to him or whatever is his own thought; but, although his vision is perfect and normal, he can not see a single printed word or a written one, whether it be written by himself or another. He recognizes the names of the letters and figures, but can not join them objectively to form words or numbers; yet he can form words and numbers mentally if the letters or ciphers are dictated to him. M. Armaignac has advised his patient to learn to read again, beginning with the alphabet; but he finds the intellectual strain of joining the letters into words and syllables very severe.

Harvest-Time.—Every season is a harvest-time in some country on the globe. In Australia, New Zealand, Chili, and some other countries in South America, the harvest takes place in January. In India, it

begins in February and is completed in March. In Mexico, Persia, and Syria, it takes place in April; in Asia Minor, Algeria, Morocco, and parts of China and Japan, in May, and after this in California, Spain, Portugal, Italy, Greece, Sicily, and some of the southern departments of France. In July it begins in France, Austria, Hungary, Poland, Russia, and the Middle United States. The turn of Germany, Belgium, Denmark, and Holland comes in August, and of Scotland, Northern America, Sweden, and Northern Russia in September.

Obituary.—Mr. Thomas Potts James, who died in February last, was one of our oldest botanists, and was one of four—Sullivant, Austin, James, and Lesquereux—who have distinguished themselves as specialists in the mosses. He was born at Radnor, Pennsylvania, in 1803. Having been prevented by circumstances from acquiring a collegiate education, as he had intended, he settled down in Philadelphia as a druggist, pursuing science as a by-occupation. He was an active member of the leading scientific societies of the city, and an officer of many of them. He made himself familiar with the phenogamous vegetation of the neighborhood of Philadelphia, and then devoted himself to the special study of the mosses, on which he contributed several papers, including the bryological department of the report of Clarence King's exploration of the fortieth parallel. He was associated with Mr. Lesquereux in the preparation of the "Manual of North American Mosses" which Sullivant was about to prepare in connection with Lesquereux when he died. Mr. James's death leaves Mr. Lesquereux the only survivor of the four American bryologists, and imposes upon him the task of completing the "Manual."

Mr. John Scott Russell, the constructor of the steamship Great Eastern, died at Ventnor, Isle of Wight, June 8th, in the seventy-fifth year of his age. He was the son of a Scotch clergyman, and was destined for the Church, but his taste for mechanics and science led him in another direction. He was graduated from Glasgow University when sixteen years old; was appointed temporary Professor of Natural Philosophy in the University of Edinburgh in 1832; communicated to the British Association his first paper on the nature of waves and the best form of vessels in 1835; and received the gold medal of the Royal Society of Edinburgh for another paper bearing on that subject two years later. As manager of a ship-building establishment at Greenock, he built several vessels after the ideas he had worked out, and constructed the Great Eastern in 1846. He became a Secretary of the Society of Arts in 1845. In 1850 he was appointed a joint Secretary of the Commission for the promotion of the Great Exhibition of 1851, and was one of the three chiefs in the furtherance of that enterprise. His greatest engineering work was the construction of the dome of the Exhibition Building at Vienna in 1873, the largest dome in the world. His last work was the design for a high level bridge with a span of one thousand feet, to cross the Thames below London Bridge. He also built the steamer that carries railway-trains across the Lake of Constance; and he contributed many valuable papers to the literature of his profession.

NOTES.

Dr. Byron D. Halstead, of the "American Agriculturist," has published, in the report of the Secretary of the Connecticut Board of Agriculture, an important memoir on "Fungi injurious to Vegetation, with Remedies." In it he describes ergot, the potato-rot, the rust of wheat, corn-smut, the onion-smut, the apple-leaf fungus, the peach-curl fungus, the American grape-mildew, the lettuce-mildew, and the raspberry fungus.

M. Barral, Secretary of the National Agricultural Society of France, has shown recently that the beet-sugar industry is advancing steadily in Germany, but is stationary in France. A great change has taken place in the character of the apparatus used for extracting the sugar in Germany, where hydraulic and continuous presses have given way to a process of extraction by diffusion, the apparatus for which is much more simple. A similar change is going on in France, but it has made less advance there than in Germany and Austria. The relative depression of the industry in France is owing to two causes: the quality of the beet-roots, which

is inferior; and the manner of laying the taxes, which in Germany and Austria bear upon the fabrication, and stimulate it to devices to improve the yield, while in France they bear upon the consumption, and tend to discourage it.

A BARK containing quinine and quinidine, and currently known as *Cuprea cinchona*, imported from Colombia, has recently had a sale in England comparable to the entire amount of the importation of cinchona-bark from all other countries. The affinities of the tree which produces it, hitherto unknown, have been traced out by M. Triana, who has found that the bark is chiefly derived from two species of *Remijia*, a genus of which no species was previously known to contain quinine. Seeds of the *Remijia* have been received, and are in cultivation at Malvern House, Sydenham. The tree is likely to prove valuable for cultivation in countries where malarial fevers abound. It grows at an elevation of from six hundred to thirty-three hundred feet above the sea, where even red cinchona will not flourish.

THE census report on fire-arms and ammunition lays stress on the advantage of the "interchangeable system" of manufacturing, or the system by which any single part is made to fit into any machine of the same class, and its influence in the development of industries. Two of our great industries, agriculture and manufactures, now depend largely upon this system, which is of American origin, and has reached its greatest development in our country. Its introduction has reduced waste and effected economy in production. By it the manufacturer is able to furnish machines of all kinds at reasonable cost, repairs are made easy and cheap; and agricultural processes, by the aid of generally available machinery, have become greatly extended. One of the direct results of the system has been a great improvement in the strength, durability, and working performances of the machines made.

M. TORCAPEL describes a formation of basalt rich in pyroxene and very hard, and more than six hundred feet thick, at Aubenas, in Ardèche, France, under which the washings of the river Rhône have exposed a succession of beds of tufa, volcanic mud, and decomposed basalt containing teeth and bones of mammals which have been assigned by M. Gaudry to the Upper Miocene. The situation of the fossils and the superincumbence of the basalt leave no doubt that the animals to which the bones belonged were contemporaneous with the eruption and its victims. The date of the latter and that of the basaltic eruptions, the outflows of which cover a large portion of the central plateau of France, may therefore be referred to the period named. M. Gaudry remarks that these conclusions agree with those reached by M. Ramers in the Cantal.

M. L. CLEMANDOT has given the name of tempering by compression to a new method of treating metals, particularly steel, which consists in heating the metal to a cherry-red, and then putting it under a strong pressure, and keeping it there till it is cooled.

THE fifth in the series of "Saturday Lectures," in the National Museum at Washington, for 1882, was by Professor Riley, and gave "Little-Known Facts about Well-Known Animals," in the form of a popular account of the life-history of the oyster and his enemies, the star-fish, the shore-crab, the common frog, the house-fly, parasitism, the mosquito, and the earth-worm.

THE report of the census shows that, in the whole United States, 14,462,431 acres of land are devoted to the cultivation of cotton, and that the total product of the country is 5,176,414 bales, or $\frac{4\cdot0}{100}$ of a bale per acre; Georgia gives the largest extent of land to the cultivation of the staple, 2,617,138 acres; Mississippi produces the largest quantity, 955,808 bales; and Louisiana gives the largest return per acre, 0·59 bale.

MR. WILLIAM MORRIS DAVIS has made, in "Appalachia," an interesting study of "The Little Mountains east of the Catskills." These mountains, which rise only one or two hundred feet above the plain, and are about two miles wide, have a complicated structure and "a charmingly picturesque surface, and in tracing out their continual changes one encounters problems of great variety and beauty. The belt they occupy "is not great in quantity but very varied in quality." Their rocks, of the Hudson River and Lower Helderberg groups, are adorned with numerous fossils; and they afford examples of the six types of surface form as determined by folded, stratified rocks; both mountains and valleys of monoclinal, anticlinal, and synclinal structure. The whole system exhibits the Appalachian character of increase of variety and abruptness of change from east to west.

THE United States produces, according to the reports of the census, 44,113,495 bushels of barley, 11,817,327 of buckwheat, 1,754,861,535 of Indian corn, 407,859,999 of oats, 19,831,595 of rye, and 459,479,505 of wheat. Of the several States, California produces the most barley, 12,579,561 bushels; New York the most buckwheat, 4,461,200 bushels; Illinois the most corn (325,792,481 bushels), oats (63,189,200 bushels), and wheat (51,110,502 bushels); and Pennsylvania the most rye, 3,683,621 bushels.

THOMAS SAY.